

sEMG BIOFEEDBACK AS A TOOL TO
IMPROVE ORAL MOTOR CONTROL AND
FUNCTIONAL SWALLOWING IN
SCHOOL AGE CHILDREN WITH
CEREBRAL PALSY: A CASE SERIES.

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ABSTRACT

The number of children with complex medical needs has risen in recent years, due to the increase in medical technology and subsequent increased survival rate of premature infants. This has led to an increasing number of children with complex neurological conditions, such as Cerebral Palsy, being seen by speech-language therapists to address their complex feeding and communication needs in schools (Arvedson 2008). Surface electromyography (sEMG) has been successfully used as a tool to facilitate therapy in adult dysphagia rehabilitation (Huckabee & Cannito 1999), and has been used in studies of dysarthric speech in children with Cerebral Palsy (Marchant, Mc Auliffe & Huckabee 2007).

This case series report examines the effect of oral motor control therapy with sEMG biofeedback to increase motor control and inhibit increased muscle tone. Three participants aged 6, 16, and 18 were selected from the population of Kimi Ora Special School. Each of the three participants were offered sixty, twice daily treatment sessions of 30 minutes each focusing on active relaxation, and reducing duration of return to reset after recruitment of the masseter and submental muscles using sEMG biofeedback. After each session each participant was fed a prescribed amount of thin fluid and a range of food textures to encourage generalization of increased control of the submental and masseter muscles during eating and drinking.

One participant was withdrawn after 42 sessions, and two participants completed all 60 sessions. Results showed variable improvement in feeding skills, with a notable improvement in anterior food loss. All participants were able to participate fully in the treatment and made

significant gains in their ability to control their muscles during treatment sessions which was reflected in the reduction of sEMG amplitudes. This study demonstrated that oral motor control therapy with sEMG is a viable treatment tool, which warrants further larger scale research into its effectiveness.

INTRODUCTION

“Cerebral Palsy is a term used to describe a group of disabling conditions, which affect movement and posture. It is caused by a defect or lesion to one or more specific areas of the brain, usually occurring during foetal development before, during or shortly following birth or during infancy” (Cerebral Palsy Society of New Zealand 2010).

The implications of Cerebral Palsy are far reaching for children and their families. It impacts on all areas of development, from sitting and crawling, to standing and walking, and most significantly to eating and drinking development. Cerebral Palsy significantly impacts on children's oral motor skills, which causes difficulty in preparing food and drinks for swallowing. The effect of feeding dysfunction or dysphagia on the growth and development of children with Cerebral Palsy has been well documented (Fung et al, 2002). Previous research has focused on the prevalence and type of dysphagia in children with Cerebral Palsy, assessment options and its impact on development and nutrition. Intervention for these identified needs has been often compensatory, including diet modifications and positioning of the child. There is a need for current research to explore new treatment options which do not just compensate for the feeding behaviors observed but which take into account and treat the underlying causes of the feeding impairment, so that more functional feeding skills can be developed.

LITERATURE REVIEW

Research into speech-language therapy and dysphagia in developmental disability is just beginning. Speech-language therapists are increasingly being expected to provide evidence and outcome measures for clinical services offered to children and adults alike (Mullen & Schooling 2010) Therefore the importance of efficacious research into any treatment program is essential. This review aims to discuss and evaluate the relevant research relating to dysphagia in children with Cerebral Palsy and treatment currently available.

Motor Planning

To discuss abnormal motor development in the context of a neurological impairment such as Cerebral Palsy, it is important to understand normal motor development. Normal motor skill development in children with no cognitive or physical impairment is a complex process that involves the learning of skills related to movement, and the use and coordination of all muscle systems within the body (Shepherd, 1995). Different researchers have suggested that there are different systems for the learning of skills and complex motor planning that occurs during normal development. Some research has argued that the acquisition of motor skills follows several phases: learning begins with a fast learning stage where a skill is learnt and performed, followed by a slow stage in which further gains can be observed across several sessions of practice of the skill (Karni et al 1998). This demonstrates that motor skill learning takes place within the context of an environment where a new skill is practiced repeatedly, and in a variety of situations, until it becomes automatic.

The capacity to plan, learn and retain new motor skills is essential for participation in daily activities. This acquisition and development of skills takes place throughout infancy and childhood, and draws from the child's experiences during daily activities. These experiences include gross motor activities (e.g. sitting, standing, crawling, and walking) and fine motor activities (e.g. hand movements, oral skills,). Motor skilled behaviors are regarded as fully automatized when actions are carried out effortlessly with no need for external prompts or resources (Doyon 2008). Normal motor skill acquisition therefore follows a progression of skill learning and generalization through childhood. Doyon (2008) examined motor sequence learning and movement disorders in his review paper. He discussed motor sequence learning and widely debated motor memory. Doyon concluded from this review that new advances are now leading to a new understanding of how motor sequencing behaviors are learned and of the impact of neurological impairment on development. Discussion about development of these behaviors now includes the different areas of the brain which are involved in motor learning, and the how these areas contribute to each stage of learning. Doyon found that during the early phase of explicit motor learning, associative frontal regions including the dorsolateral prefrontal cortex and rostral premotor areas, as well as associative basal ganglia and cerebellum are recruited. Doyon also examined the role of the basal ganglia in movement disorders such as Parkinson's disease. He argued the need for consideration of the different brain structures involved in motor sequence learning from a therapeutic perspective.

Other researchers such as Coynel et al (2010) take this further and have examined the later stages of motor learning, which they argue involves the sensorimotor cortex. Therefore motor learning takes place in a series of stages, with the early stages of learning recruiting the basal

ganglia and cerebellum and later stages then recruiting information provided by the sensorimotor cortex.

Researchers such as Hadders-Algra (2000) have proposed a dynamic systems theory, which suggests that motor development does not follow a predetermined course but is affected by many different factors. These factors include body weight, muscle strength, joint configuration, mood, environmental conditions, and brain development (Hadders-Algra 2000). This would be relevant to an examination of populations where brain damage has occurred as the systems affected by damage will then impact on motor learning and development. As these systems follow a then disordered pattern of development, due to the neurological damage, the impact of different factors suggested by Hadders-Algra become less apparent.

There is much debate regarding the different systems of motor planning. The literature discussed above shows how environment, neurology and the stages of motor development systems can all play key roles in the understanding of motor planning in normal development. These systems then need to be evaluated in abnormal development, and the consequence of any impairment highlighted, to provide a sound basis for research.

Cerebral Palsy

Cerebral Palsy is recognized as one of the most common developmental disabilities in childhood. The prevalence of Cerebral Palsy in New Zealand is 2.0 to 2.5 per 1,000 live births. Approximately 7,000 people in New Zealand are diagnosed with some degree of

Cerebral Palsy. One third of these are under 21 years of age (Cerebral Palsy Society of New Zealand 2010).

Cerebral Palsy is the term used to refer to a non-progressive group of brain disorders resulting from a lesion or developmental abnormality in early fetal life or early infancy (Shepherd 1995). More recently, in 2005, a committee of the American Academy for Cerebral Palsy and Developmental Medicine (AACPDM) defined Cerebral Palsy as “a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of Cerebral Palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behaviour, and/or by a seizure disorder.” (Bax 2005, pg. 572). This definition is more comprehensive as it takes into account the functional result of the brain injury, and is the definition of Cerebral Palsy used in this study.

Cerebral Palsy is typically characterized by poor control of movement, and is classified clinically in terms of the part of the body affected, and by the perception of tone and involuntary movement (Brouwer & Ashby 1991). This can lead to functional definitions such as spastic hemiplegia (one side of body and high tone) and ataxic quadriplegia (all four limbs and fluctuating tone).

Using the parameters of lesion site and functional consequence as recommended above Spastic Cerebral Palsy can be defined as a result of bilateral damage to the pyramidal and

extra-pyramidal tracts of the central nervous system. This presents as increased tone (known as spasticity), weakness and a reduced range of volitional movement to muscles of the limbs and orofacial region (Bialik & Givon, 2009).

The impact of Cerebral Palsy on gross motor function has been widely defined in research using the Gross Motor Function Classification System (GMFCS) (Palisano et al 1997). The GMFCS is a 5-level classification system that describes the gross motor function of children and youth with Cerebral Palsy on the basis of their self-initiated movement with particular emphasis on sitting, walking, and wheeled mobility. Distinctions between levels are based on functional abilities, the need for assistive technology, including hand-held mobility devices (walkers, crutches, or canes) or wheeled mobility, and to a much lesser extent, quality of movement. It was first developed in 1997 and in 2007 was expanded to include age groups of 12-18yrs. This system has been used in a variety of studies to measure and define the degree of impact of motor function of Cerebral Palsy (Gorter, Verschuren, Van Riel, & Ketelaar, 2009; Kim & Park, 2011; Van Wely, et al., 2010).

Development of functional activities in Cerebral Palsy

Cerebral Palsy has a significant impact on gross and fine motor development and causes subsequent movement difficulties which can lead to difficulties in daily activities. Research from an occupational therapy viewpoint such as Smits et al (2010) evaluates the impact of Cerebral Palsy on daily activities. Smits and his colleagues used the Pediatric Evaluation of Disability Inventory Functional Skills Scale (PEDI-FSS) to monitor development of daily living and functional skills over a three year period. Its initial aim was to describe the course

of capabilities in self-care, mobility, and social function over a two year period in school-age children with CP (5–9 years). They also aimed to find models that would predict progression within these areas. For example in self-care they found the course was best predicted by a model including a level of gross motor function capacity (in this case the GMFCS as mentioned previously) and intellectual ability. An area of interest to this study is that the PEDI does have a section on feeding, but this is not directly quoted or discussed in this study, which is interesting as feeding is a key daily activity, and would therefore have been interesting to follow in a longitudinal study such as this. This highlights a need for more focused research into feeding and Cerebral Palsy

Spasticity

Spasticity is one of the main impairments noted in children with Cerebral Palsy and impacts on both gross and fine motor activities. Ostensjo et al (2004) discussed the complex relationship between spasticity, range of movement, and selective motor control. Ostensjo argued that previous research defined spasticity in Cerebral Palsy by measuring a single muscle group. However his study provides evidence that it is necessary to look at multiple muscle groups and to take into account range of movement to provide a more robust description. Malhotra et al (2009) conducted a systematic literature review taken from research conducted between 1980 to 2006. They emphasized the need for further research and greater clarity when using spasticity as a term to describe the result of an upper motor lesion leading to increased muscle tone and underlying muscle weakness. Spasticity affects all muscle movements, from gross motor movement of the arm and legs to fine motor movements such as grasp, and oromotor movements. This could support the argument, from

researchers such as Malahotra and colleagues, that when defining and treating spasticity it is important to look at more than one muscle group and different ranges of movement in order to affect change in an activity.

Treatment of Spasticity

Tilton (2009) discusses various treatment options, including physiotherapy focusing on functional movement, skill based treatments, casting, and constraint therapy. Tilton also discuss interventions such as oral medications, chemodenervation, intrathecal baclofen, selective dorsal rhizotomy, and orthopedic surgery. Tilton notes that the most efficacious interaction combines a range of different options, depending on the individual client's needs. This supports the need for a treatment approach that encompasses a range of complementary techniques.

Feeding Development and development of feeding in children with Cerebral Palsy

Eating and drinking is a complex process that requires the use and co-ordination of many cranial nerves, muscles and structures. Normal feeding development follows a sequential acquisition in oral skills and development of coordination and movement of the structures involved in swallowing. From 0 -2 years children acquire the skills required to eat and drink a variety of textures (Winstock 2005). The development of feeding skills and that of the motor system are not independent; for example, an infant must be able to hold their head up before they can learn to chew.

It can therefore be argued that any delay or disorder of motor development will impact on the development of feeding skills. When applied to children with Cerebral Palsy, their physical needs therefore impact on their ability to coordinate their oral movements and contain food within their mouths whilst preparing it for swallowing.

Researchers such as Arvedson and Lefton-Greif (1996) state that knowledge of anatomy, physiology, and normal development of feeding skills is basic to the assessment and management of pediatric dysphagia. It is important to be aware when analyzing neurologically impaired children that they do not follow a normal pattern of development, and may have disordered anatomy and physiology. Therefore any research needs to start from a model of normal development and then take into account abnormal functioning based on differences found.

Definitions of "dysphagia"

Different researchers use different terms for defining dysphagia. Recently Gisel (2008) defined dysphagia as “eating impairment” including oral motor dysfunction, swallowing impairment and weight gain or loss. This demonstrates how the term dysphagia can be used as an umbrella term for all aspects of difficulty with feeding, not just the pharyngeal stage. Schwarz (2001) uses the label ‘feeding disorders’ when discussing feeding difficulties in children with developmental disabilities. This highlights the need for clear definition in discussion and research into the impact of developmental disability in eating and drinking. To be consistent, dysphagia is defined in this study as impairment in some or all areas of the

eating and swallowing process; oral, oral transit, pharyngeal and esophageal stage.

Dysphagia and Cerebral Palsy

Reilly et al (1996) examined the incidence of feeding problems in children with Cerebral Palsy in more detail. In her community survey, Reilly evaluated a representative sample of 49 children and found the majority had clinically significant oral motor dysfunction which had an adverse effect on mealtimes and made it difficult for some children to achieve satisfactory nutritional intake. In 60% of these children, feeding diagnosis preceded their diagnosis of Cerebral Palsy. However, this study covers a relatively small sample based on descriptive and anecdotal data. Calis and colleagues assessed clinical indicators and severity of dysphagia in 194 children with severe generalized Cerebral Palsy and intellectual disability (Calis, et al., 2008). Calis et al used a standardized screening assessment, the Dysphagia Disorders Survey (DDS) (Sheppard 2002), which had been modified for the purposes of the study. The DDS uses a range of information to screen for signs of dysphagia in all phases of swallowing. Calis and colleagues found the severity of Cerebral Palsy correlated with the DDS score and the severity of dysphagia. Calis et al demonstrated that it was feasible to use a screening assessment for participants with Cerebral Palsy to successfully identify indicators of dysphagia within a research study.

Both of these studies document the high risk of dysphagia and feeding dysfunction in children with Cerebral Palsy. Researchers such as Veness and Reilly (2001) have also commented on the wide reaching implications of feeding impairment in children with Cerebral Palsy. They surveyed 20 mothers of children with Cerebral Palsy with the aim of

evaluating mealtime interaction. They found that longer mealtimes as a result of feeding impairment, specifically poor oral skills, led to a breakdown in positive interactions between mother and child. For children with moderate to severe Cerebral Palsy, multiple studies have shown that feeding dysfunction is a common problem associated with poor health and inadequate nutritional status (Gangil et al 2001, Fung et al 2002, and Hou et al 2004). Therefore the treatment of feeding dysfunction for this population is a vital area for investigation.

Recent studies such as Erkin et al (2010) have also argued a link between the level of gross motor impairment and severity of feeding impairment in children with Cerebral Palsy. Erkin and her colleagues evaluated 120 children with Cerebral Palsy, using range of criteria including length of mealtimes, diet modifications and GIS problems. They also rated the level of feeding impairment mild, moderate or severe. Erkin and colleagues concluded that feeding impairment was most prevalent in children with a high level of gross motor impairment, as measured by the GMFCS. The results indicated lack of appetite in 38.3% of the children, sialorrhea in 30.8%, constipation in 25%, difficulty in swallowing in 19.2%, and feeding dysfunction in 21.7%. They concluded that approximately one fourth of children with Cerebral Palsy suffer from feeding dysfunction.

Poor weight gain and inadequate nutrition is frequently reported in children with Cerebral Palsy (Kuperminc & Stevenson 2008). This is most commonly due to poor oral-motor coordination, resulting in inadequate caloric intake. This would lead to the use of Body Mass Indicator (BMI) to assess for possible feeding difficulties and dysphagia. BMI is a measure

of weight by height to give a score, which is then applied to a range of ‘normal’, ‘underweight’, ‘overweight’ etc. In a study examining “Nutritional Correlates of Dysphagia in Individuals Institutionalized with Mental Retardation” (Sheppard et al 1988), Sheppard et al found BMI to be the best predictor of severity of dysphagia in this population. To this date no further studies found have highlighted BMI as clearly.

The Dysphagia Disorders Survey (DDS) (Sheppard 1998) is the only screening assessment available to trained speech-language therapists which has been standardized on a population with developmental disability. The user manual states that it is applicable for ages 2 to 21, in pediatrics and for adults with developmental disability. Sheppard also notes that for pediatric use the child has to be of an age when the typical child would be eating all food types and have all developmental eating skills. The DDS is split into two parts. Part One, Related Factors, documents factors that are pre-indicators to Dysphagia such as head stability, postural control and body mass index (BMI). It also records compensatory factors for Dysphagia such as adaptive utensils, dietary modifications or tube feeding. Part two, Feeding Competency, screens for physical evidence of Dysphagia at each stage of the swallow and on fluids non-chewable and chewable solids. The assessor observes a minimum of 5 mouthfuls of each texture: a point is given for an abnormal feeding behavior and zero for normal. These scores can then give a percentile ranking in relation to others with developmental disability. The DDS is therefore a valid screening tool to aid assessment and diagnosis of dysphagia in children with Cerebral Palsy. As previously noted it has been used successfully to identify dysphagia in children with Cerebral Palsy in studies such as Calis (2008).

Intervention and management of identified Dysphagia

There is a range of current intervention techniques used by therapists to manage and treat children with feeding impairment and dysphagia. Intervention can consist of compensatory techniques such as diet modification, positioning of the child and use of specialized utensils (e.g. an adaptive cup). These interventions often address the symptom of the dysphagia rather than its underlying cause. An example of this is diet modification, such as pureeing food, for children who are unable to chew. Research has shown pureed foods can be problematic for children as lack of exposure to chewable foods reduces the opportunities to learn chewing (Beckett et al 2002). Researchers also warn against focusing solely on aspiration and encourage practitioners to look at swallowing function, physiology and co-ordination when creating management plans (Smith 2007). Lefton-Grief & Arvedson (2008) argue that intervention should take place in collaboration with the medical team surrounding the child. In their survey of speech-language therapists working within these settings they found there was limited evidence for the interventions being implemented among this complex population. This is possibly due to the wide range of feeding disorders presented by children with complex needs which also supports the argument for more research into intervention techniques for this population.

An early case study by Butterfield and Parson (1973) used behavioral techniques including shaping, positive reinforcement and modeling to successfully teach an 8 year old participant with Downs Syndrome to chew solid foods. Butterfield and Parsons' case study has limited external validity as it is single subject study, however it is important as it begins to address

specific oral motor issues in feeding (although the initial level of oral motor dysfunction of the individual treated is not recorded).

Other studies have also evaluated specific techniques to address oral motor dysfunction during eating. In a series of studies Gisel and her colleagues evaluated an intervention focused on three main areas of oral motor functioning; tongue lateralization, lip control and vigor of chewing in children with Cerebral Palsy (Gisel 1994, Gisel Applegate-Ferrate, Benson, & Bosma 1995 Gisel, Applegate-Ferrate, Benson, & Bosma 1996). These studies evaluated the effect of 10 or 20 weeks of 5-7 minutes of daily sensorimotor treatment on the growth, eating efficiency and aspiration in children with Cerebral Palsy. The results of all the studies showed an improvement in chewing, but limited significant gains in growth. Gisel also argues that it is beneficial to use food stimuli in treatment of oral motor dysfunction as it creates a more natural eating reaction than non-nutritive chewing objects such as chewy tubes.

Pinnington and Hegarty (2000) evaluated the effect of using an electromechanical device to ensure consistent optimal food presentation to 16 children with severe neurological impairment. All children had a neurological impairment which presented with a quadriplegic distribution of either athetosis or spasticity, with 13 having a diagnosis of Cerebral Palsy. Pinnington and Hegarty found statistically significant differences in three components of oral motor behavior assessed; duration of oral motor events, range and control of movement, and control of mastication and swallowing. The researchers concluded that it was possible for

children with severe neurological impairment to acquire previously undeveloped oral motor skills.

Eckman, Williams, Riegel and Paul (2000) used elements of Gisel and Butterfield's interventions, as mentioned previously, to create a structured treatment approach to teach chewing in two subjects with developmental disability. This treatment used behavioural techniques and specific oral motor exercises to teach chewing in one child with Downs Syndrome and another child with unspecified developmental disability and complex medical needs. Both participants improved their chewing skills and increased the range of foods in their diet, which was maintained post-treatment. Parent and caregivers were trained in the techniques used to help support continuation of the gains made in the intensive treatment period of the study. Eckman and his colleagues support Gisel's theory of real food item use during treatment and also argue that this prevents issues with generalization.

Surface Electromyography (sEMG)

Electromyography can be simply defined as a technique for evaluating and recording the electrical activity produced by skeletal muscles (Jablecki 1986). An electromyograph detects the electrical potential generated by muscle cells when these cells are neurologically activated. This signal is also known as a Motor Action Unit Potential (MUAP). The signals can be analyzed to detect medical abnormalities, activation level, and recruitment order or to analyze the biomechanics of human or animal movement. In sEMG electrodes placed on the skin surface collect MUAPs from the underlying muscles which are then processed by a

decoder and displayed on a computer using an appropriate software programme. This amplitude is then displayed in microvolts (μV).

sEMG has many applications and has been widely used in physiotherapy as part of biofeedback treatment for a range of impairments, including back, knee, leg and arm disorders. It has also been applied in work based upper extremity disorders, where researchers such as Nord et al (2001) find preliminary support for its use as an approach, and advocate the need for more controlled trials for its use in rehabilitation. sEMG is also used as a tool in gait analysis as reviewed by Frigo et al (2009). Gomes et al (2009) reviewed available literature between 1996 and 2009 and demonstrated through the studies they found the importance of using sEMG as a method of feeding assessment for term and preterm infants.

sEMG has recently become more widely used in rehabilitation for adults with dysphagia and has been shown to be a valuable tool to help adults understand and modify their swallowing behaviors. Research into the use of sEMG biofeedback in adults with stroke has found that it is most effective when used for a covert activity (Nelson 2007). This supports the argument that a tool such as sEMG makes an abstract concept like swallowing more concrete by providing a visual image. This can then be applied to children with Cerebral Palsy. This is because children with Cerebral Palsy and resulting cognitive impairment often find it difficult to comprehend abstract concepts. This is especially difficult when dealing with abstract concepts such as swallowing and tone when trying to adjust their feeding behaviors.

Huckabee & Cannito (1999) have demonstrated that physiological change in the swallowing mechanism can be achieved with a structured swallowing treatment programme, including the use of sEMG. The use of instrumentation in rehabilitation is highly recommended for adult dysphagia and equipment such sEMG, as a non-invasive tool, has increased over recent years.

Marchant et al (2007) evaluated sEMG as a tool to facilitate a reduction in labial and lingual hypertonicity and consequently improvement of articulation. In this study, a combination of phonetic placement therapy (PPT) and relaxation therapy using sEMG demonstrated clinical improvement in the participants single word articulation, despite no perceptible changes to overall intelligibility. The researchers concluded that the severity of the participants' dysarthria was a factor in the minimal changes observed following treatment. They also stated future studies examining the treatments in children with mild and/or moderate dysarthria were required. Marchant and her colleagues study is the only example of research directly evaluating sEMG, relaxation therapy and spastic Cerebral Palsy in relation to speech it demonstrates a significant gap in current research into treatment for children with dysphagia and spastic Cerebral Palsy and the potential for a new programme which could address this.

Only one other study to date has used relaxation therapy with sEMG to address spasticity. This was conducted by McGrath (1979), as part of an unpublished post graduate thesis. McGraths' study evaluated the use of an electromyography with six hemiplegic children. These children were treated for periods of up to half an hour, twice a week for six weeks. The

treatment focused on relaxation of the opposing muscles involved in bending the forearm. This study found that despite their cognitive impairment the participants were quickly able to utilize the treatment and achieve relaxation of their forearm muscles. McGrath concluded that the subsequent relaxation led to a reduction in spasticity and an increase in functionality of these limbs and balance of movement, measured by a change in range of movement. Interestingly the results of this study document that the participants were able to improve their balance in their lower limbs by reducing spasticity, although these muscles were not directly treated in any way. McGrath's study has some limitations, due its limited sample size and lack of control groups. It does however document the successful use of electromyography within the population targeted within this study, and provided interesting insights into the use of this treatment approach to reduce spasticity.

Both McGrath and Marchants' studies provide an introduction to the use of electromyography and sEMG as a possible treatment modality for children with Cerebral Palsy. Neither study comments on the use of this approach to target feeding competency, despite the large amount of research data available on the impact of feeding difficulties within Cerebral Palsy on both children and their caregivers. In order to address this, Marchant and her colleagues' use of sEMG-facilitated biofeedback relaxation treatment could arguably be applied to children with Cerebral Palsy and oral phase dysphagia.

This study hypothesized that by reducing spasticity with active relaxation therapy, using sEMG as a modality, the participants would gain more control over their muscles. This would

then lead to more efficient voluntary utilization of the muscles and will facilitate a measurable change in the oral phase of feeding in children with Spastic Cerebral Palsy.

Research Hypothesis

This study hypothesized that:

1. Active relaxation of increased muscle tone with sEMG as a biofeedback modality would facilitate the development of increased motor control in children with spastic Cerebral Palsy.
2. Increased motor control attained during motor control therapy targeting the submental and masseter muscle groups would have an observable impact on the participants' oral skills on chewable, non-chewable and thin liquids post-treatment as measured by a change in scores on the Dysphagia Disorders Survey (Sheppard 2002).
3. The participants would show an improvement in containment of bolus during the oral stage post-treatment as measured by a decreased amount of anterior bolus loss.

METHOD

Research Design

A descriptive case series research design was used for this study. This study contains three single case studies following a consistent treatment design in order to examine the effect of motor control therapy with sEMG biofeedback to increase motor control and inhibit increased muscle tone. It aimed to demonstrate a causal relationship between treatment and a change in feeding behavior for each participant. The research design follows the defined criteria for constructing single case research, which includes assessment, an experimental treatment design and data evaluation (Kazdin 2011).

Ethical considerations

Ethical approval was gained from the New Zealand Health and Disability Ethics Central Committee prior to recruitment of participants (See Appendix A).

Recruitment

Participants were selected from the population of Kimi Ora Special School, where the researcher was based. Kimi Ora is a full time school for children with complex physical and learning needs. The students at Kimi Ora follow a modified school curriculum, and receive daily input from an in-school transdisciplinary team of speech-language therapists, physiotherapists and occupational therapists.

Inclusion Criteria for participants

- a) Be aged between 5 and 21 years

- b) Attend Kimi Ora School full time
- c) Have a diagnosis of spastic Cerebral Palsy made by a pediatrician
- d) Have an identified oral stage dysphagia, diagnosed by a Speech-Language Therapist and/or pediatrician.
- e) Demonstrate understanding of basic prepositions including on and under, and understanding of the following adjectives; tight, loose
- f) To be able to follow simple commands relating to body movements e.g., open and close mouth, bite down.
- g) Have hearing and vision within normal limits

The upper range of 21yrs was chosen as it is the age students at Kimi Ora School graduate to adult services.

Three students out of the thirty four enrolled at Kimi Ora School met the inclusion criteria.

Their parents were approached by their designated class teacher to see if they would consider being a part of the study. Information sheets and consent forms (see Appendices B and C) were then sent home.

Informed Consent

The information sheet was explained to the participants face-to-face and to their parents face to face or via telephone by the researcher. Time was allocated for any questions to be raised, and the parents were aware of their right to raise issues or concerns or to withdraw their child from the study.

Consent - Participants

Informed consent was also gained from the participants. Specially designed information and consent sheets for the participants were discussed with each participant and consent given by placing their mark on the sheets provided (see Appendices D and E). Cognitive impairment was compensated for by the use of clear simple language tailored to the participants' level of comprehension, and with the use of visual aids. Symbols were used to illustrate the key points with the information and consent forms. All families and participants approached gave their written consent to participate in the study.

Participants

1. John*

John's ethnicity is described as Pacific Island on his school enrollment form. He is male and 18yrs old. He has a diagnosis of spastic quadriplegic Cerebral Palsy and mild cognitive impairment by a pediatrician. His pediatrician has also recorded hearing and vision within normal limits in his medical reports. John is rated as IV on the GMFCS (Palisano et al 1997), as he has limited self-mobility and uses a powered wheelchair. John has epilepsy, is on no ongoing medications, but has diazepam for use in an emergency for a grand mal seizure. John has oral phase dysphagia, identified via clinical assessment and videofluoroscopy (VFS) by two speech-language therapists. This impairment is characterized by poor bolus formation and inadequate glossopalatal seal leading to premature spillage of the bolus into the pharynx of all textures. He has a documented history of post swallow aspiration of thin fluids on VFS. John is a dependant feeder. John has good comprehension of language as assessed informally

* All names have been changed to protect the participants' identities.

and documented in his speech-language therapy case notes by his therapists. He is severely dysarthric but able to communicate his wants and needs using eye pointing, head movement and vocalizations. He uses a Vantage computerized communication device to send more complex messages, and can communicate in sentences using this device. He receives daily speech therapy, physiotherapy and occupational therapy support in school

2. Clare*

Clare's ethnicity is described as New Zealand European on her school enrollment form. She is female, and 16yrs old. She has a diagnosis of spastic quadriplegic Cerebral Palsy by a pediatrician who also reports she has a mild- moderate cognitive impairment. Her pediatrician has also recorded hearing and vision within normal limits in her medical reports. Clare has epilepsy, is on no ongoing medications, but has diazepam for use in an emergency for a grand mal seizure. Clare is rated IV on the GMFCS, as she has limited self-mobility and is transported in a manual wheelchair at school and the community. She has oral stage dysphagia, characterized by significant anterior loss, poor bolus formation and mastication. Clare is on a normal to soft diet, as her feeders do not give her hard to chew foods. Clare is a dependant feeder. Clare has significant difficulties attending and listening as reported in her speech-language therapy case notes. Clare is severely dysarthric and communicates using a range of single words with variable intelligibility. She also communicates by vocalizing yes and no, pointing to objects and by pointing to symbols to make choices and indicate her wants and needs. She is currently learning to use a Springboard computerized communication device, but is not yet reliable in using it competently.

* All names have been changed to protect the participants identities

3. *Simon**

Simon's ethnicity is NZ European as described on his school enrolment form. He is male and 6yrs old. He has a diagnosis of spastic quadriplegic Cerebral Palsy by his paediatrician who also reports he has age appropriate cognition. His paediatrician has also recorded hearing and vision within normal limits in his medical reports Simon has a rating of V on the GMFCS, as he is transported manually in a wheelchair and requires assistive technology for adequate positioning and support. Simon has a history of infantile seizures, is on no on-going medications, but has diazepam for use should he have a seizure in school. Simon has oral stage dysphagia, characterized by significant anterior loss, poor bolus formation and impaired mastication documented in his speech-language therapy case notes and reports. Simon is a dependant feeder. He is currently on a soft diet, with some hard foods such as biscuits given under supervision. Simon is non-verbal and communicates by using a range of adapted makaton signs, head movements and eye pointing. He uses symbols and photos to make choices by pointing and to indicate his wants and needs.

Procedure:

Each case study consisted of the following stages: an introductory session, a baseline assessment, treatment period, a mid-treatment assessment, another treatment period then a final assessment. The planned treatment timeline is detailed in the following table:

Table 1: Assessment and Treatment Timetable

Time	Assessment/ Treatment Phase
Day 1	Baseline assessment
Day 2 -17 (Treatment Sessions 1-30)	Treatment period (10 times a week over 3 weeks)
Day 18	Mid-treatment Assessment
Day 18 – 33 (Treatment Sessions 31-60)	Treatment period (10 times a week over 3 weeks)
Day 34	Post-treatment assessment
4 weeks after final treatment session	One month post-treatment assessment

The treatment consisted of a 6 week program of twice-daily treatment for five consecutive school days per week, to total 60 sessions of treatment. Five days out of a possible seven each week was designated to maximize attendance to sessions maximize input and to keep the environment stable. If a session was missed due to absence or events outside of the researchers' control, treatment continued at the next available opportunity to ensure completion of a maximum of 60 sessions. As prolonged absence would significantly influence outcomes, if a participant missed 10 consecutive sessions they were withdrawn from the study.

Environment

All treatment and assessment sessions took place in the same room. This room had been cleared to reduce distractions. For treatment sessions, the main light was turned off and

computer charger unplugged to reduce cross talk from the charger to the electrodes. The sEMG equipment was set up on a small table in front of the participant with the researcher sitting next to the participant on their left hand side.

sEMG Baseline Assessment:

Equipment

A portable sEMG device using a Pro Infiniti™ decoder, was used to obtain peak sEMG amplitudes, in microvolts (μV), of the collective submental (floor of mouth) and masseter (jaw) muscle groups. Alcohol skin cleansing wipes were used to prepare the participants skin. One MyoScan Pro™ 1600 sensor was used with an extender cable with 3 single cables. Duotrode Electrodes were used on the target muscle and a single ground electrode on the earlobe. Biograph Infiniti, version 5.3, was used on a laptop computer as the software platform for data acquisition.

Assessment Procedure:

For assessment the participant was placed in an upright position with the computer screen out of view. The participants head and neck were aligned and support was given if the participant was unable to maintain adequate head control and support for feeding. Photographs were taken at the initial introductory session to ensure replication of electrode placement for each following session.

The electrodes were placed in four positions:

1. Overlying the collective submental (floor of mouth) muscles.

2. Overlying the right masseter muscle
3. Overlying the left masseter muscle
4. A ground electrode on the earlobe

These particular electrode placements were chosen as they measure activity from the muscles contributing significantly to oromotor dysfunction in children with Cerebral Palsy (Gangil, Patwari, Aneja, Ahuja, & Anand, 2001) Therefore it was hypothesized that any change in tone and function of these muscles as a result of motor control therapy with sEMG would correlate with a change in feeding function on the DDS, and also in the anterior loss assessment.

To gain as accurate a reading as possible several factors were considered by the researcher when attaching the electrodes:

- (1) Proximity of a the electrode site to underlying muscle
 - (2) Alignment of the electrodes parallel to muscle fibre direction
 - (3) Ensuring a sealed and clean electrode attachment to a proposed site without interference, for example from skin folds, skin oil or hair
 - (4) Minimizing cross talk from adjacent muscles and equipment (Fridlund & Cacioppo 1986).
- For example the laptop was unplugged from the power cable during the sessions and the tube lighting in the room was switched off.

Two tasks were evaluated in the baseline assessment:

Task 1 was a resting baseline sEMG reading across a 60 second time period. Each participant was asked to sit still and relax for just over 2 minutes, with no view of the biofeedback tracing. At 30 seconds, 60 seconds, 90 seconds and 120 seconds a 10 second measure of amplitude was taken. These 4 measurements were then used to calculate the average resting amplitude across the 2 minutes of relaxation.

Task 2 represented a measure of brief, purposeful muscle activity of the submental and masseter muscles (jaw opening, and biting down respectively). The participants were told to relax, then to either open their mouth or bite down, then return to relaxed posture. The time taken to return to a consistent resting point for duration of 5 seconds was then measured. These measurements were taken pre, mid, and post-treatment. The masseter with the highest degree of spasticity was targeted for treatment.

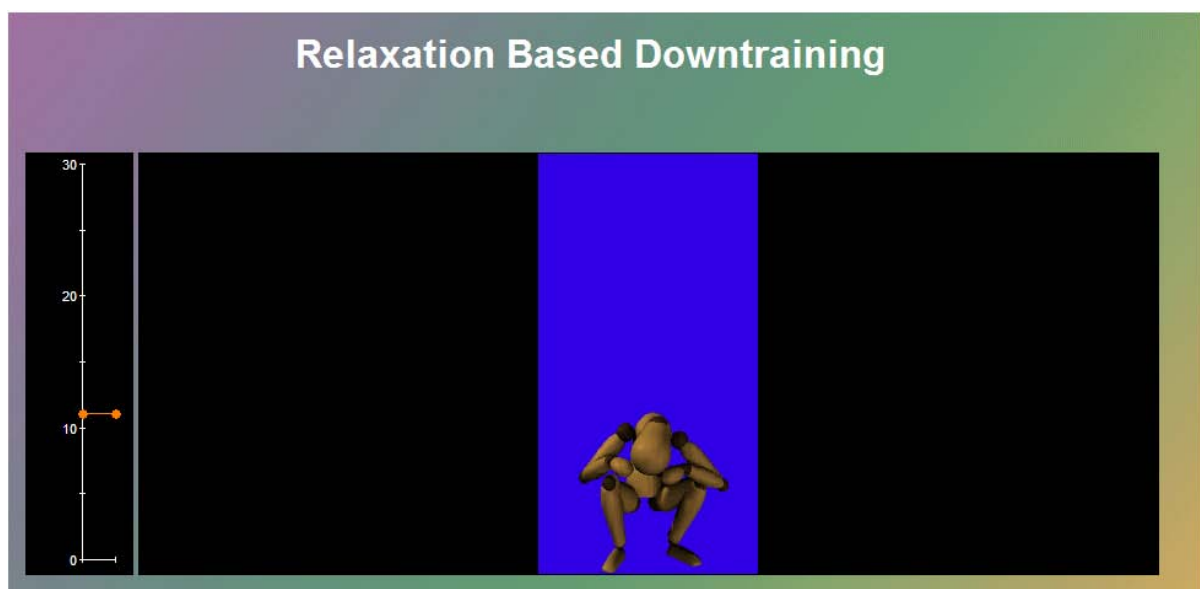
Treatment Program

This study trialed motor control therapy involving the use of sEMG as a tool to teach the participants to control tone by learning to relax/inhibit spasticity. Three screens were specifically designed by the researcher and the development team from the equipment manufacturer to maximize their use for this study. Each screen had a session timer at the bottom right corner.

- Screen One (Session baseline calculation) = Simple waveform, featuring an onscreen calculator for mean amplitude at 10 second intervals

- Screen Two = Single waveform with a single horizontal adjustable threshold line. This screen also displays current amplitude in microvolts μV . It has an audio option to enable music to play if waveform is kept under threshold line.
- Screen Three = Animation of a man with adjustable threshold. This was set to stand up if amplitude is above threshold to represent increased tone (see figure) and to fold down towards the floor if amplitude was below threshold to represent relaxation (see figure 1).

Figure 1: Man animation when participant achieved below threshold



Changes to initial protocol

The initial therapy protocol was intended to work on both target muscle groups within each session. In practice this was not feasible as this would have made treatment time on each muscle group too short and possibly ineffective. Therefore the decision was made to work on one muscle group per day for participants John and Simon. As Clare found it more difficult to attend and participate due to her higher level of cognitive impairment it was decided to work on one muscle group consecutively for 10 sessions before changing. This was to maximize

her learning opportunity. Each participant received a total of 30 sessions on each target muscle group.

Session Outline

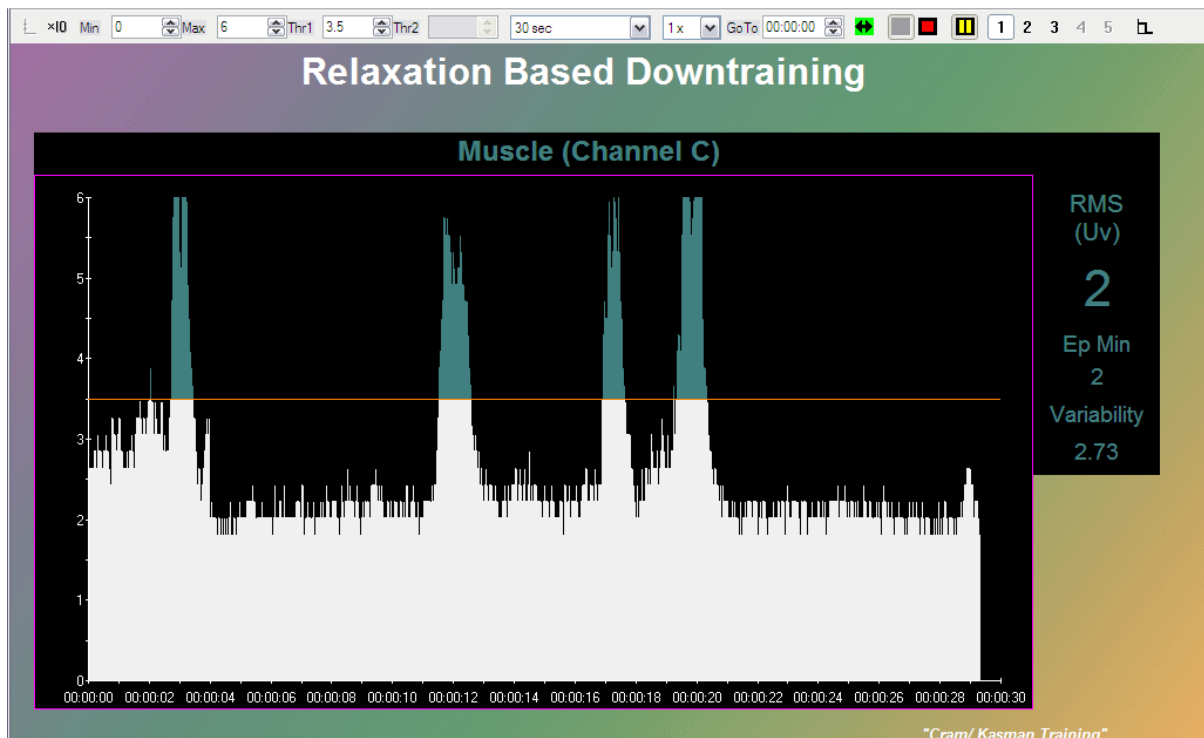
Preparation:

The electrode site was cleaned using an alcohol wipe. As a post-adolescent participant, John was shaved when necessary under the guidance of the schools Occupational Therapist. The session aims were reviewed using symbols as reinforcement for comprehension of tasks. The understanding of commands given during sessions was reinforced using a short task in which the participant was asked to point to a choice of two symbols e.g. point to the symbol “ I am tense”, “I am loose”.

Oral Motor Control Therapy:

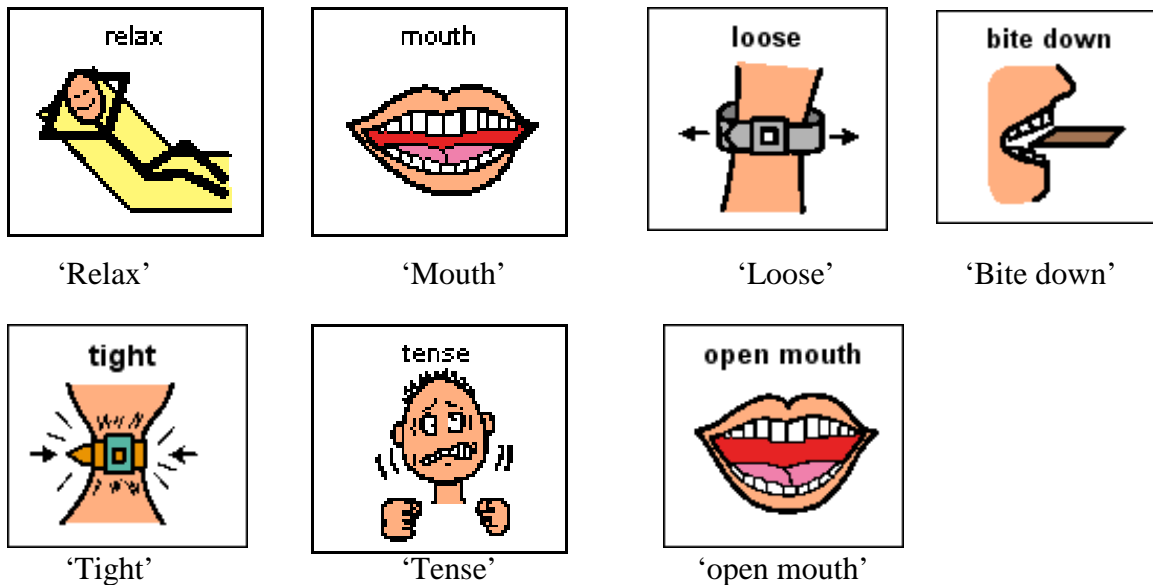
Each treatment session initially focused on reducing masseter and/or submental sEMG amplitude during rest. After ten session an additional second task was introduced targeting duration of return to rest after muscle recruitment. The participants used sEMG waveform software which creates a cartoon image of a man sitting or standing depending on the degree of muscle activity as measured by sEMG. An adjustable threshold was also used, and the option of music to play when the subject achieved below threshold was available.

Figure 2: sEMG amplitude wave form with adjustable threshold line at 3.5



For each session the aims and expectations were explained to each student and simple questions were asked to ensure comprehension of the tasks and terminology used. Visual supports of Picture Communication Symbols (PCS), created by the software program Boardmaker version 5 (Meyer-Johnson 2000) were used to further support comprehension of each task and to compensate for cognitive impairment. All the participants in this study used symbols in their everyday routines.

Figure 3: Examples of Visual Supports for tasks:



Session Baseline

For each session a resting baseline was calculated across two minutes as per the sEMG assessment protocol. The computer screen was positioned out of view of the participant. The baseline was calculated as per the protocol detailed for sEMG assessment of task 1.

Treatment Session

The screen was turned to face the participants. The difference between 'tense' and 'relaxed' was demonstrated by asking the students to open their mouths (submental) or bite down (Masseter) and the resulting peak sEMG amplitudes in the waveform were discussed. During the first two sessions the researcher also applied electrodes to themselves to demonstrate for the participants how the software works and to relate the muscle movements to those on screen. Participants were then instructed to relax and keep their waveform as flat as possible. They were also told to try and keep their waveform under the threshold line. Consistent

language including ‘let go of your teeth and relax’ (masseter)’ or ‘keep your mouth relaxed’ (submental) was used to explain that when the participants’ teeth or mouth were relaxed the waveform stayed flat. Positive reinforcement was given. The music threshold was activated after one consistent thirty second screen where appropriate. When the participants were able to focus and maintain a flat waveform under threshold for three thirty-second screens out of four the threshold was lowered. For example if the threshold was set at 7 μ V and the participant consistently achieved between 5 μ V and 6 μ V the threshold was lowered to 6 μ V. If the participant failed to achieve below threshold the threshold was increased to 0.5 above the level they were able to achieve to ensure success and avoid the participants motivation decreasing. After 5 minutes if the participants had been focussing consistently, the screen was switched to the animation. The participants then practised keeping the animated figure relaxed and on the floor. As with the waveform screen the threshold was lowered when relaxation was achieved for three periods of thirty seconds out of four. A stopwatch was used to time duration and to provide further reinforcement and encouragement for the participants to increase the duration of relaxation.

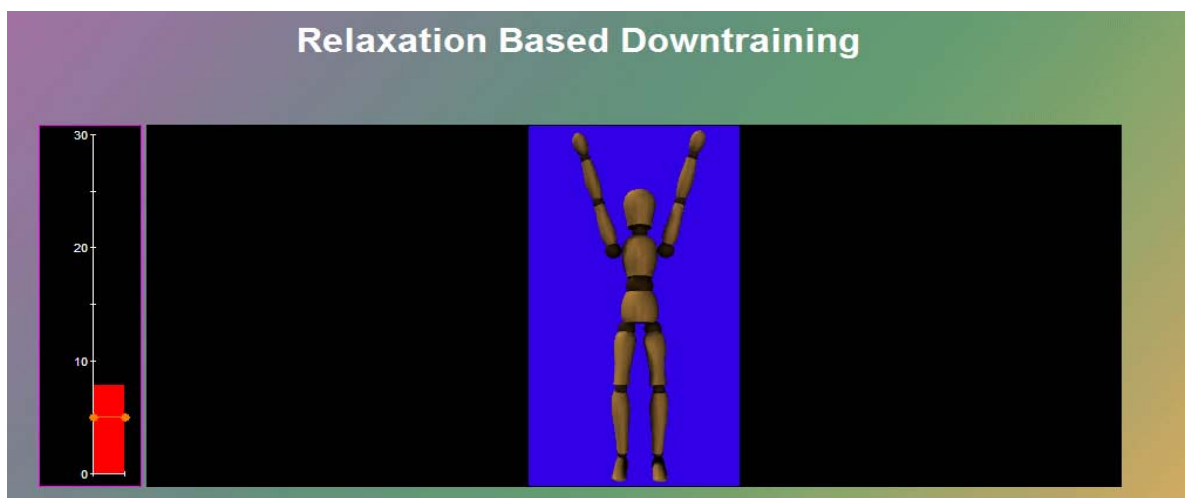
After the first ten sessions of treatment using task one were complete task two was introduced. From this point the sessions then comprised of twelve minutes of task one, 12 minutes of task two and 2 minutes of relaxation to complete the session.

For the first two sessions the researcher applied electrodes and demonstrated the task. The participants were told to sit still and relax. An instruction to activate the targeted muscle was then given. This was either “relax, bite down, then relax as quickly as you can” or ‘relax open

your mouth and close and relax as quickly as you can”. For the first five repetitions the waveform screen was used. The researcher commented on the peak of sEMG amplitude and how quickly the participant could return to a flat line after the peak sEMG amplitude.

After 5 minutes the researcher changed to the animation screen where the participants practised relaxing the animated figure to the floor and making him stand up by biting down or opening their mouths and then returning to relaxed as quickly as possible. A stop watch was used to give further feedback on time.

Figure 4: Man animation demonstrating participant recruitment of masseter muscle



Once the participants were able to perform the task on both screens they were given a choice of which screen they wished to use, but both screens were used in every session.

Post-treatment Feeding:

After each therapy session the participants were fed by the same teacher aide:

- 20mls water (thin fluid)
- 6 teaspoons (30g) of yoghurt (non chewable)
- 4 pieces (20g) of banana (soft chewable)
- 6 (6g) pieces of a Nice™ brand biscuit (hard chewable)

Each participant was fed by a teacher aide allocated to them for the whole treatment period.

Feeding each participant post-treatment gave them the opportunity to practice using their muscles post relaxation. The ranges of textures were chosen as they represent the range of oral skills involved using the muscle targeted. The researcher ensured that feeding took place within five minutes of the session ending.

Outcome Measures:

Three outcome measures were completed pre-, mid-, post- and one month post-treatment

1. The Dysphagia Disorders Survey (DDS) (Sheppard 2002)
2. A measurement of Anterior Loss
3. A Perception Scale Questionnaire completed by parent/caregivers and school feeders.

1. DDS

The DDS was scored by a trained speech-language therapist not directly involved in the study using the guidelines for administration as detailed in the DDS manual. Identical food and fluids were used for each assessment. A quiet empty therapy room was used to minimize

distraction. A teacher aide familiar to the participant fed whilst the Speech-Language Therapist observed, and the same teacher aide fed for each assessment to ensure consistency. The researcher was not present for any of the DDS assessment.

Part 1 – Related Factors

In this study, particular note was taken in any change of BMI, as an indicator of weight gain or loss, which may indicate an improvement in feeding efficiency.

Part 2 - Feeding Competency

This section screens for physical evidence of dysphagia at each stage of the swallow on fluids, non-chewable and chewable solids. The assessor observed a minimum of 5 mouthfuls of each texture, giving one point for an abnormal feeding behavior and zero for normal. Special note of containment (point 10) and chewing (point 13) were taken during this study as they were particularly relevant to the population being discussed in this research, and to the muscle groups being targeted in the treatment.

2. Anterior Loss

Objective measures of anterior loss were obtained by feeding each participant a prescribed amount of a range of textures consistent with their normal diet and weighing their clothing protector pre and post each texture. A percentage of food or fluid lost was then calculated by subtracting the pre-feeding weight of the clothing protector and the previous amounts loss of each offered texture. For example post-yoghurt clothing protector = 121, therefore minus 6g juice (116g), and minus 110g weight of clean protector = 5g loss of yoghurt. The total

amount offered was measured by weighing the bowl, plate or cup post feeding to subtract any residue left from the initial amount offered.

The foods were chosen to represent each major food texture, fluids, non-chewable and chewable (soft and hard), and the descriptors chosen to match those of the DDS to ensure consistency and clarity of definition. The amounts and types of food given to each participant are detailed in the table below. Due to his difference in age, size and bite and utensil size the amounts were reduced for the youngest participant, Simon.

Table 2: Type and amount of fluid and food given during anterior loss measurement

	Fluid	Yoghurt	Banana	Biscuit
John	50mls orange juice	92g (8 spoonfuls)	36g (6 bite-size pieces)	11g (8 bite size pieces)
Clare	50mls orange juice	92g (8 spoonfuls)	36g (6 bite-size pieces)	11g (8 bite size pieces)
Simon	30mls apple juice	50g (8 spoonfuls)	20g (6 bite-size pieces)	6g (8 bite size pieces)

The same scales, cups and spoons were used for each assessment to ensure consistency of equipment. Using different scales each time, for example, would invalidate the results as they could measure differently.

3. Perception Scales

A perception scale was designed to evaluate functional feeding skills and the school adult and home feeders (parent) perception of the participant's skill and participation. The questions were constructed with clear wording which aimed to reduce the risk of the rating not reflecting the true behavior of the participant. Both parents and school feeders' perception was recorded so they could be compared to gain more accuracy in measurement of behaviours.

The first two questions evaluated oral skills which related to the muscle groups targeted. The remaining four evaluated the perception of general wellbeing of the person being fed, and of the feeders own level of comfort in feeding them. The six questions were presented on separate sheets of unbound paper and the parent/caregiver or school feeder was asked to place a mark crossing the lines below to represent their responses to each question. Visual analogue scales were used. The scales were marked at endpoints only (0 and 10); with 0 being the lowest possible score and 10 the highest.

Table 3: Perception scale questions and rating scales

Question	0 =	10 =
1. How well do you think your child chews food before they swallow it?	Doesn't Chew	Chews very well; thoroughly
2. How well does your child keep food their mouth whilst eating?	Keeps no food	Keeps all food
3. How successful do you feel your child is at feeding?	Unsuccessful	Very successful
4. How happy are you with your Childs eating?	Very Unhappy	Very happy
5. How much does your child appear to enjoy eating and drinking?	Does not enjoy at all	Enjoys very much
6. How comfortable are you feeding your child?	Very uncomfortable	Very comfortable

Reduction of external variables:

All assessments involving each participant took place in a quiet empty therapy room.

The participants were fed by their assigned teacher aide, who fed at all of the assessments.

The same utensil, foods and positioning of participant and feeder was used for each assessment. The assessments took place at the same time of day. For the DDS, John was assessed when he arrived at school (9am), whilst Clare and Simon were assessed at lunch time (between 12.30pm and 1.30pm). John was assessed at a different time due to assessor availability. For anterior loss all participants were assessed at morning tea break (between

10.40am and 11.30am). The perception scales were given to the parent/carer or teacher aide on the day corresponding to the phase in treatment and received back the next morning before sessions commenced or recommenced.

All participants continued their regular therapy programs in school during the study, with the exception of spa treatments. Receiving a spa session before a treatment session could additionally aid relaxation, and would therefore impact on the validity of treatment and measurement, Therefore for the duration of treatment spa sessions were postponed until after the 2nd treatment daily session and post session feeding.

Detailed case notes were completed after each session documenting baselines, task outlines, and outcomes of the session. This case notes enabled the researcher to document any positive or adverse event, and to monitor consistency of administration of the therapy protocol.

Additional Data Collected from baseline sEMG:

The researcher collected sEMG baseline data at each assessment point to document the participants developing skill level in using the equipment, and as evidence of improved motor control. In this study the sEMG data is not used as an outcome measure but still provides some additional information to be discussed in relation to oral motor control.

RESULTS

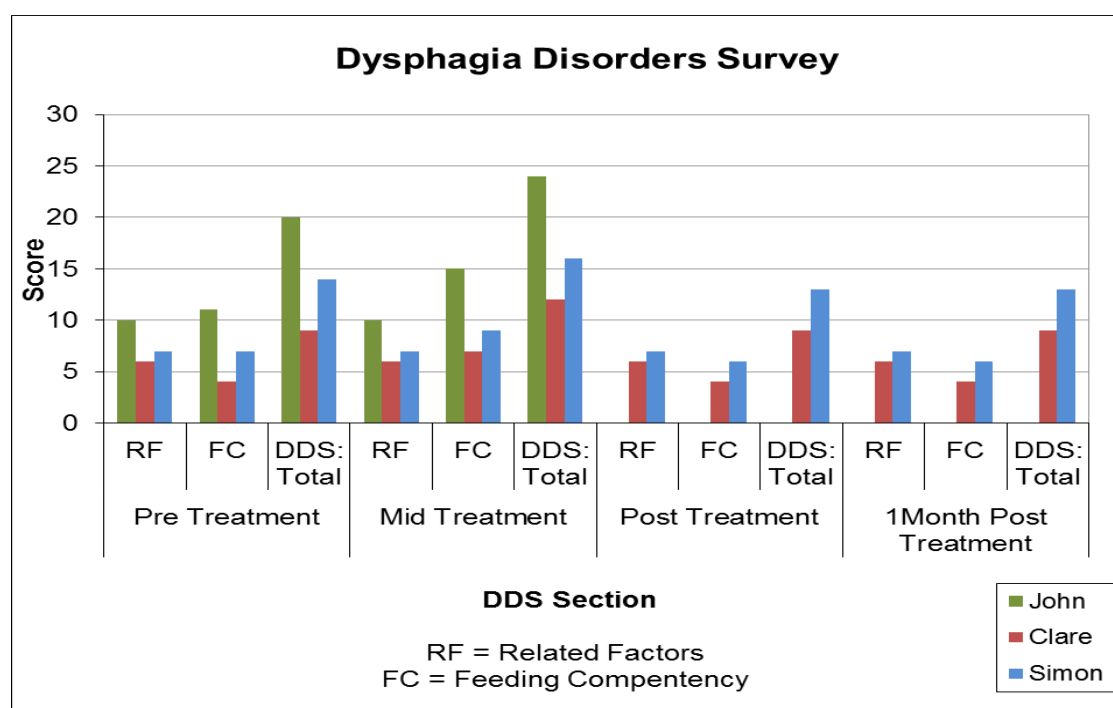
Participation

John completed 42 treatment sessions. He then was unable to attend 10 consecutive treatment sessions due to ill health resulting in absence from school. As per the research protocol, he was excluded from the study. His results therefore end at the mid-treatment assessment, and he shows a score of 0 on all the results graphs for post and one month post-treatment. Clare and Simon completed the full 60 sessions and all assessments.

1. Dysphagia Disorders Survey (DDS)

The three participants' individual scores for Related Factors (RF) and Feeding Competency (FC) on the DDS are displayed in the graph below:

Figure 5: Individual scores for Related Factors and Feeding Competency on the DDS



All subjects' scores for related factors remain constant throughout the study. John's scores demonstrate a decline in feeding competency before he was withdrawn mid-treatment. Clare's and Simon's scores demonstrate a decline in feeding competency mid-treatment but then improve post-treatment, and maintain this improvement one month post-treatment.

The table below displays the percentile rankings in relation to others with developmental disability, as calculated from the standardised scores in the DDS users' manual. Both Clare and Simon remain in the same percentile throughout the study, whereas John's significant decline in feeding competency results in his transition to the 85th-90th percentile.

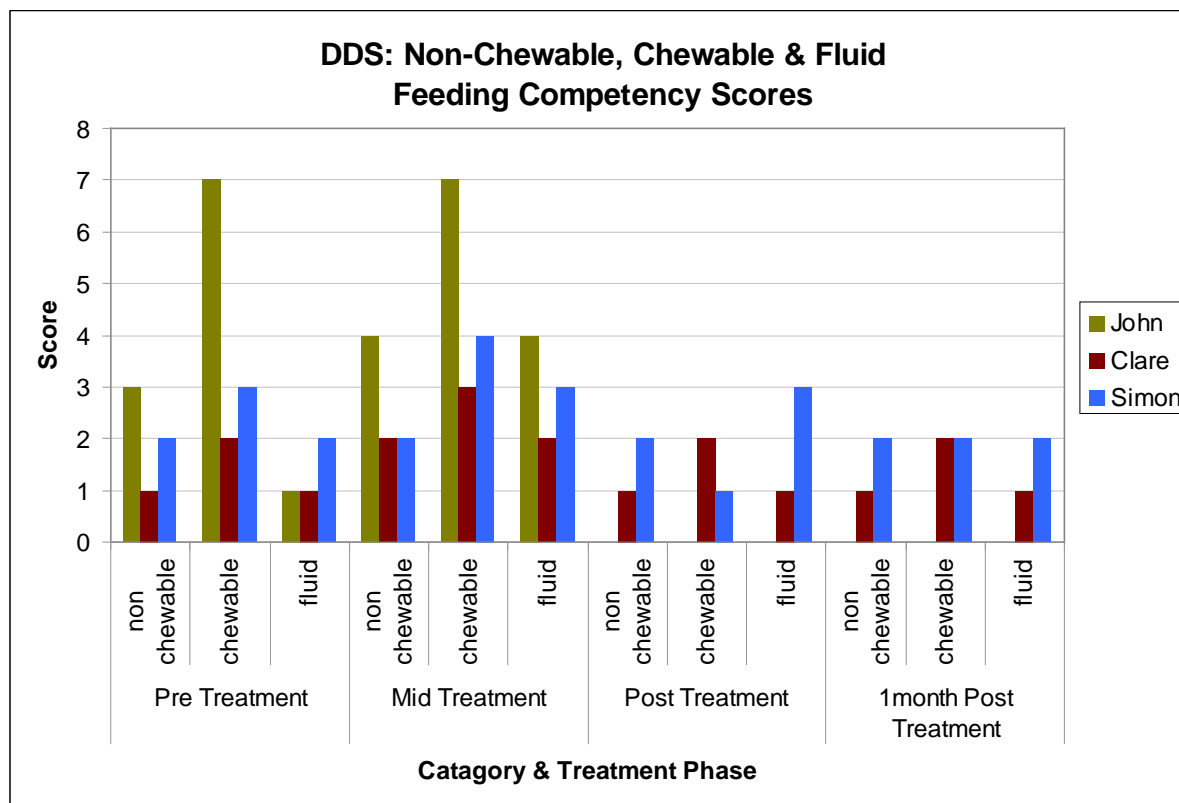
Table 4: Percentile rankings of DDS scores

	Pre-treatment	Mid-treatment	Post-treatment	1Month Post-treatment
John	75-85 th	85 th -90 th	n/a	n/a
Clare	50 th	50 th	50 th	50 th
Simon	50 th -75 th	50 th -75 th	50 th -75 th	50 th -75 th

Non Chewable, Chewable and Fluid DDS scores:

The graph below illustrates the change in scores for each food or drink type screened by the DDS.

Figure 6: Non Chewable, Chewable and Fluid Scores on DDS

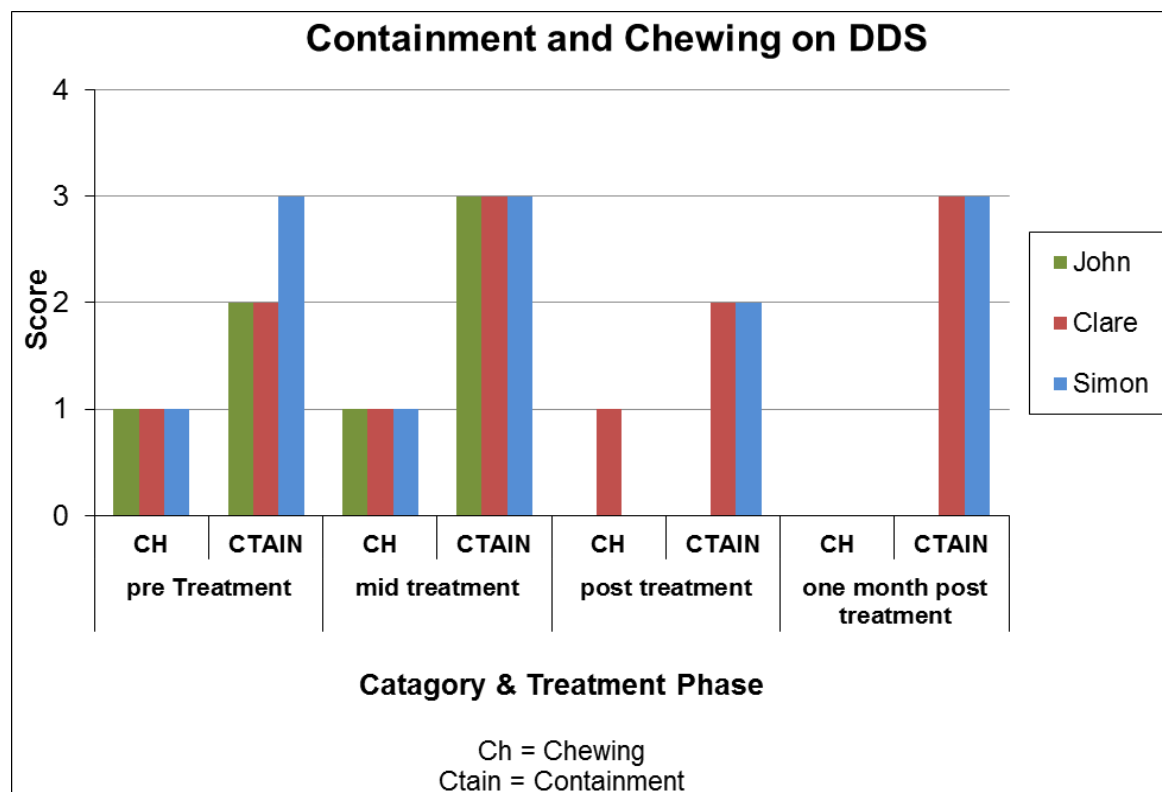


All participants demonstrate some changes in scores on the textures screened by the DDS across the study. John's scores show a general increase in abnormal scores for chewable and fluid items. Simon and Clare's scores demonstrate an increase in abnormal points for chewable items mid-treatment, but then an improvement post-treatment, with Clare returning to her pre-treatment scores one month post-treatment. Simon demonstrates an improvement one month post-treatment on chewable solids from his pre-treatment assessment.

Containment and Chewing on the DDS

A comparison between containment and chewing ability in all three participants is displayed in the graph below:

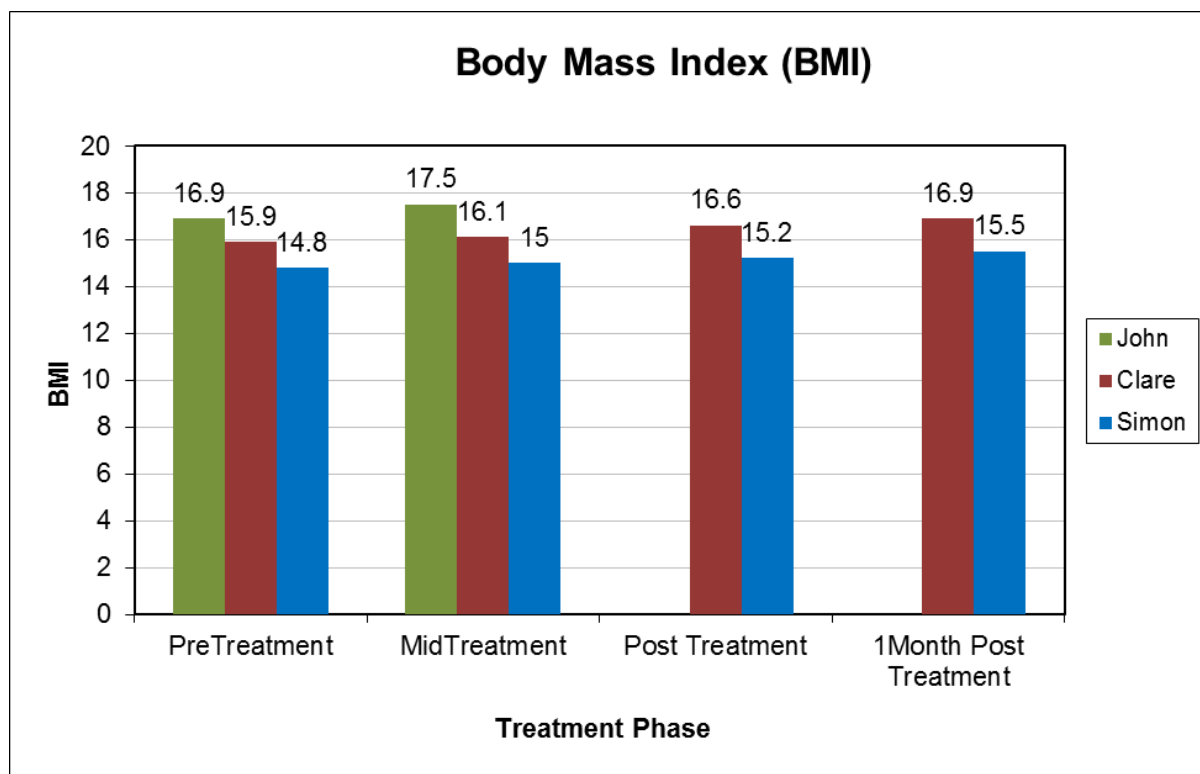
Figure 7: Containment and Chewing on DDS



All three participants scored abnormal for chewing pre and mid-treatment. Clare and Simon both achieved a normal score one month post-treatment. Both Clare and John show a decline in skills to a maximum of 3 abnormal scores in fluid, non-chewable and chewable textures mid-treatment. Post-treatment both Claire and Simon improve to score normal for containment of non-chewable, to reduce their abnormal scores to 2. However they then regressed to abnormal containment scores in all textures one month post-treatment

Body Mass Index (BMI)

Figure 8: Body Mass Index Scores



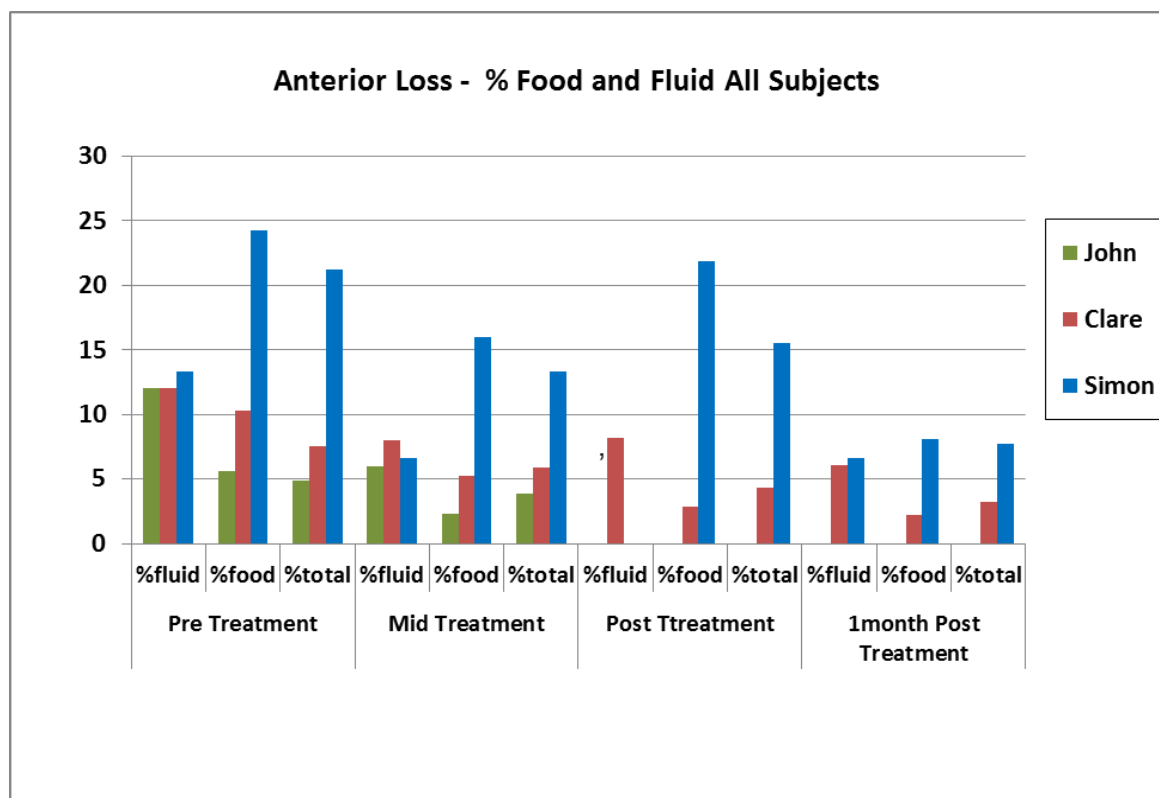
John's BMI was calculated using the adult, and Clare and Simon the child and teen, online BMI calculator of the Centers for Disease Control and Prevention (2011)

Simons BMI remained in the healthy range throughout the study. John and Clare's BMI rating were classified underweight throughout the study (Centers for Disease Control and Prevention 2010)

The graph displays a steady increase in BMI for all participants. This was due to a continual increase in weight gain by all participants across the treatment period which continued for Clare and Simon one month post-treatment.

2. Anterior Loss

Figure 9: Percentage of food and fluid lost – all subjects



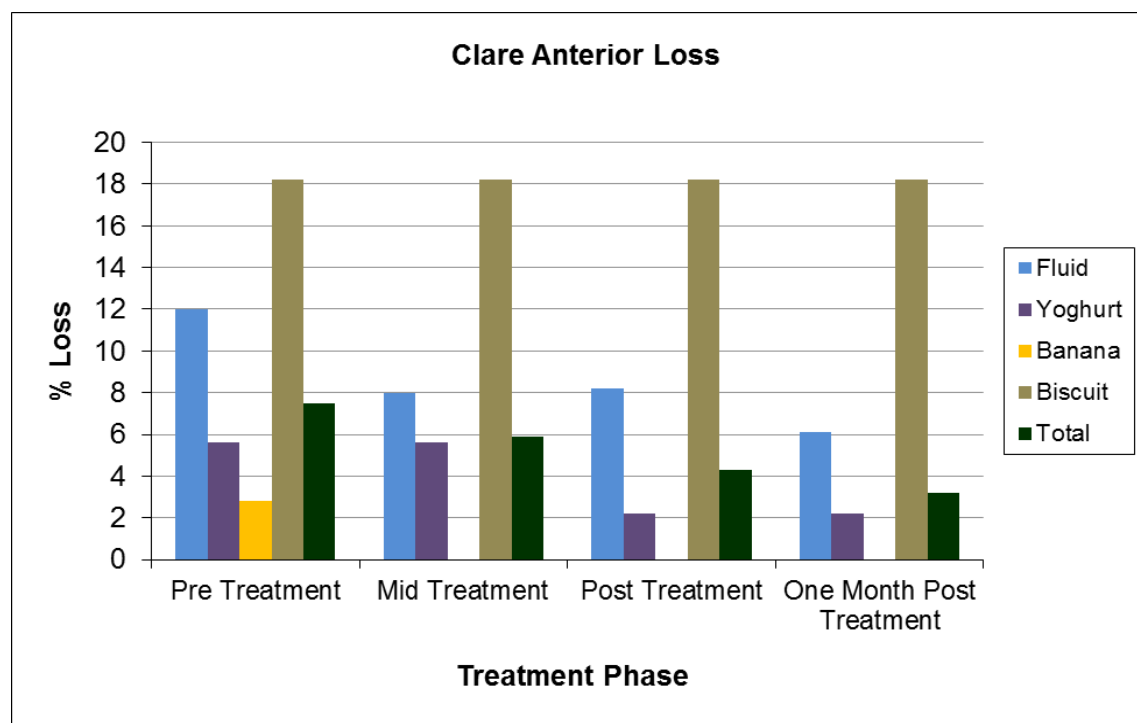
As displayed in the graph above John's anterior loss percentages for fluid notably decreases mid-treatment. He also shows an improvement in the amount of food lost, this is reflected in an overall reduction his combined percentages through the study.

Clare shows a steady improvement in her anterior loss percentages for food across all assessments. She maintains this improvement one month post-treatment. For fluids she shows an improvement from an initial 12% to of 6.1% of fluid lost one month post-treatment. Overall Clare's total fluid and food loss improves consistently across the study.

Simon shows a significant improvement reducing his anterior loss of fluids to 0% lost post-treatment. One month post-treatment he then returned to his mid-treatment score of 6.6% fluid lost. Simon's anterior loss for food lost decreased from 24.3% pre-treatment to 16% mid-treatment. This then increased to 21.9 post-treatment and reduced to 8.1% total food lost when anterior loss was measured one month post-treatment.

To analyze this data in more detail it is useful to compare fluid and the different types of food measured for each participant. This is only possible for Clare and Simon as John's foods were mixed together to a mashed consistency as per his normal diet

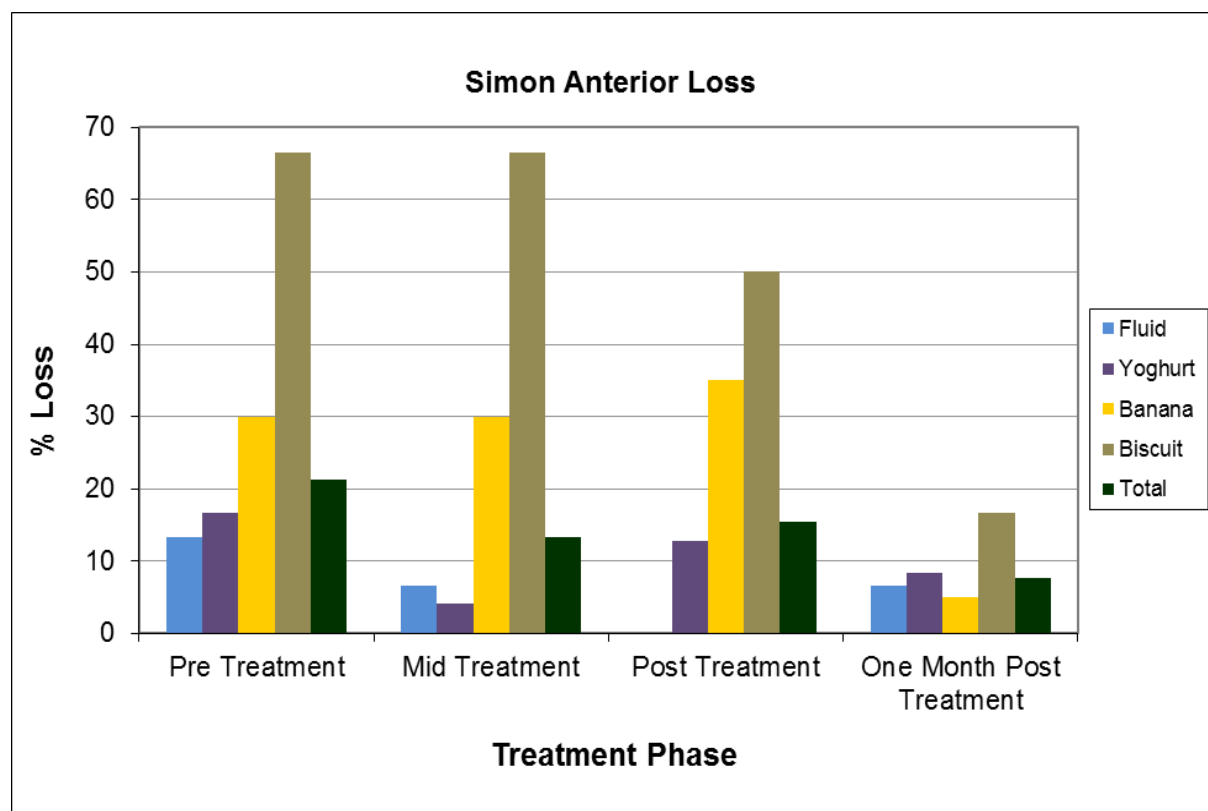
Figure 10: Clare - Percentage Anterior loss by food Type



Clare shows a significant reduction in anterior loss for yoghurt and banana, but stayed at the same percentage of biscuit throughout the study. Her fluid loss showed a significant reduction of anterior loss at one month post from her pre-treatment baseline.

As displayed in the graph below Simon's data shows a similar trend to Clare of reducing his anterior loss of yoghurt. However, in contrast, his anterior loss of banana does not improve until one month post. As with Clare, Simon's anterior loss of fluids improved overall from his pre-treatment percentage, but he did show a slight regression one month post-treatment from his 0% lost in his post-treatment assessment.

Figure 11: Simon - Percentage Anterior loss by food Type



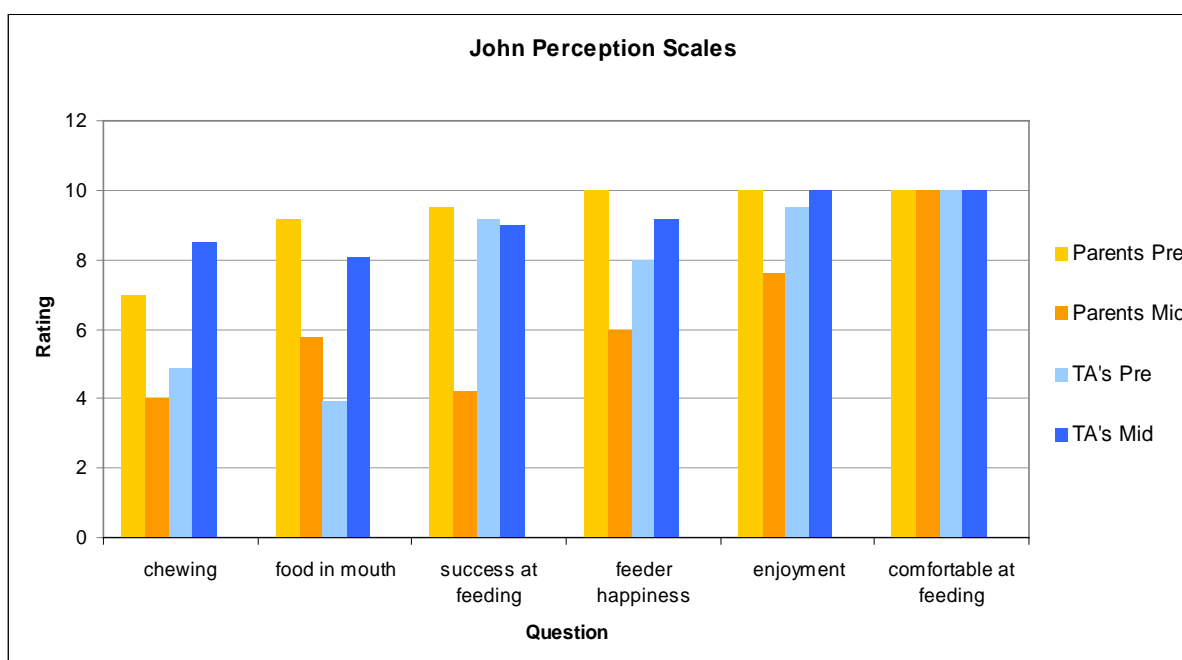
Perception Scales

The six questions addressed in the perception scales were:

1. How well do you think your child chews food before they swallow it?
2. How well does your child keep food in their mouth whilst eating?
3. How successful do you feel your child is at swallowing?
4. How happy are you with your child's feeding?
5. How much does your child appear to enjoy eating and drinking?
6. How comfortable are you feeding your child?

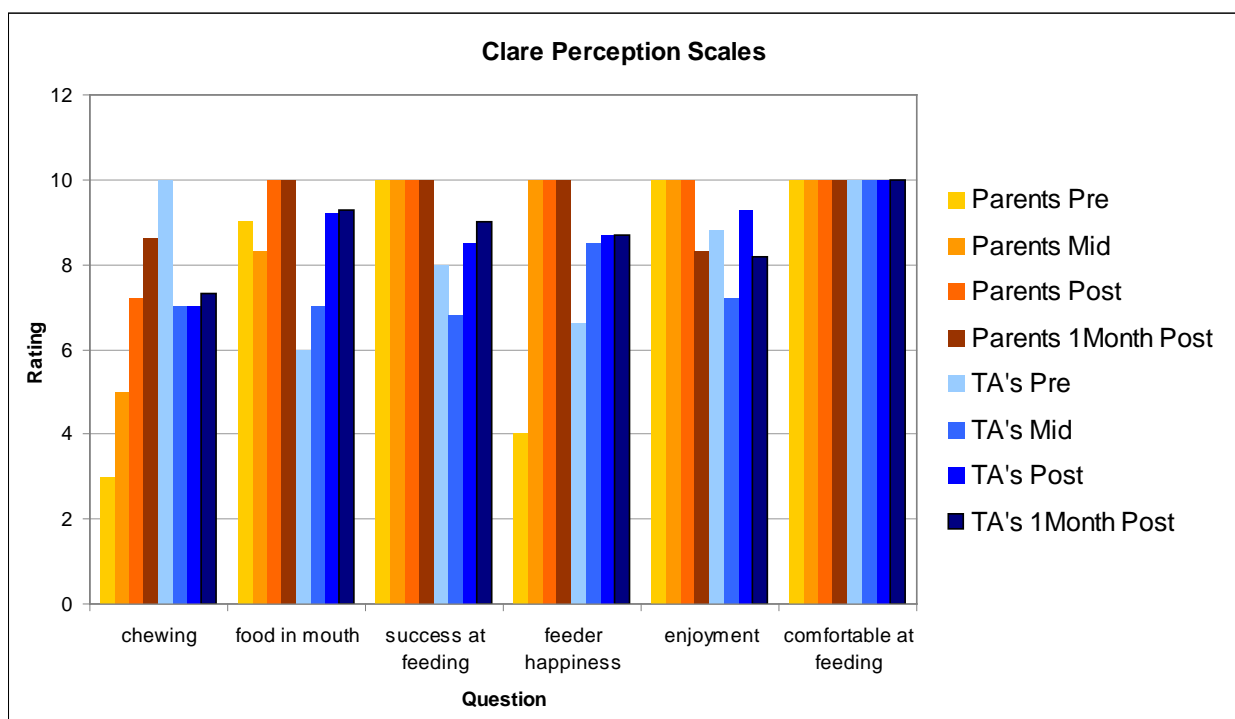
The graph below displays the perception scales ratings for John at pre and mid-treatment assessments:

Figure 12: John Perception Scales Ratings



John's parents' ratings fall across questions 1-5 throughout the study. In contrast his teacher aide ratings increase, charting an increase in ability with the exception of question 3. The only area in which John's parents and teacher aide are in agreement is in consistently scoring a maximum of 10 for their level of comfort in feeding John.

Figure 13: Clare - Perception Scales Ratings



Clare's data also shows some contrasting ratings given by her parents and teacher aides. Her parents tend to rate her higher, however both parent and teacher aide note an improvement in all areas post-treatment. As with John, both Clare's parents and teacher aide give a maximum rating of 10 for their level of comfort in feeding her across all stages of the study post-treatment.

Figure 14: Simon – Perception Scale Ratings



As displayed in the graph above, Simon’s parents chart a slight reduction in chewing ability. In contrast, his teacher aide rates a steady improvement across the study. For all other questions Simon’s teacher aide rates him as steadily improving. His parent and teacher aide agrees in this for containment. For question four to six however his parents tend to note a period of decline with lower ratings mid-treatment, whereas his teacher aid scores continue to steadily improve.

Additional data collected – sEMG baselines

Figure 15: John - Average Resting Amplitude – Task 1

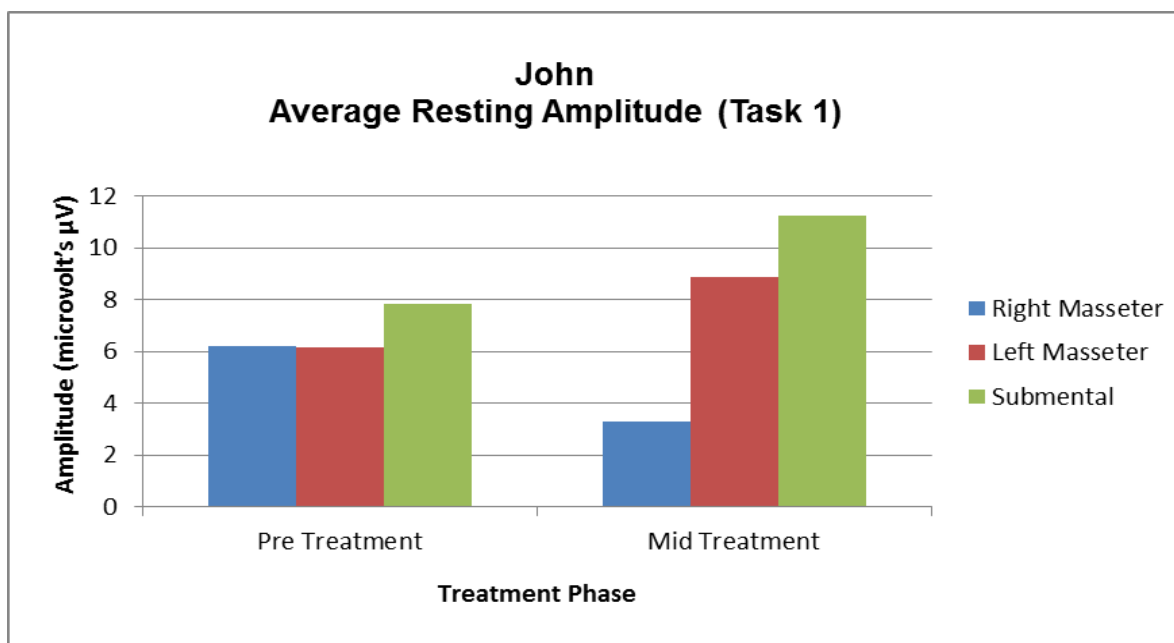


Figure 16: Clare - Average Resting Amplitude – Task 1

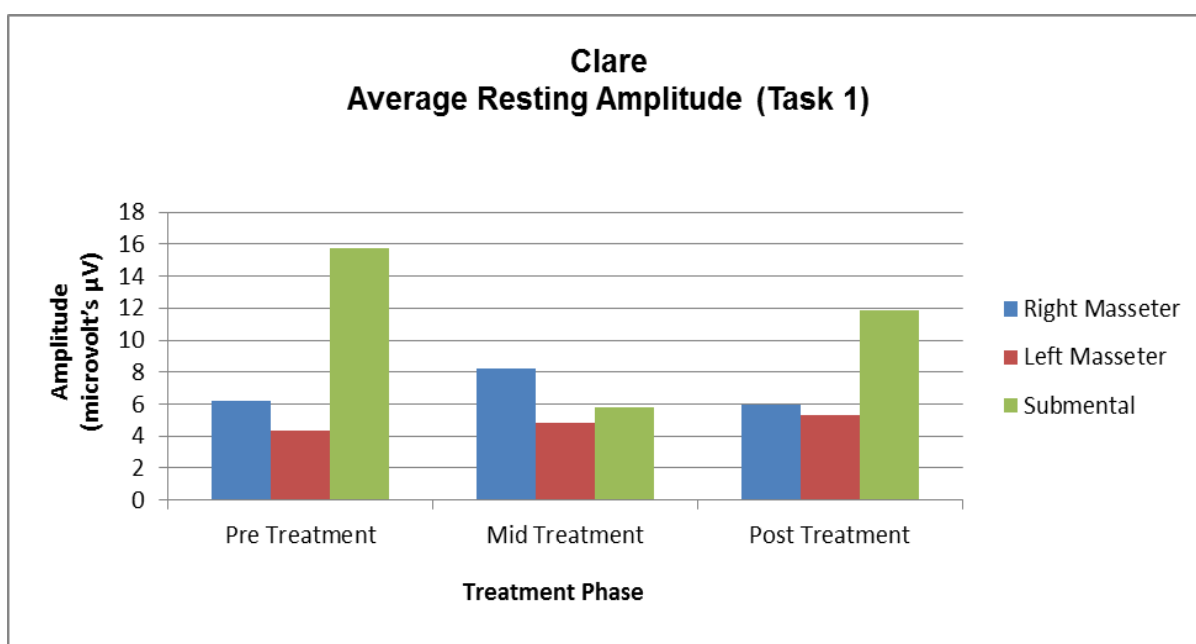
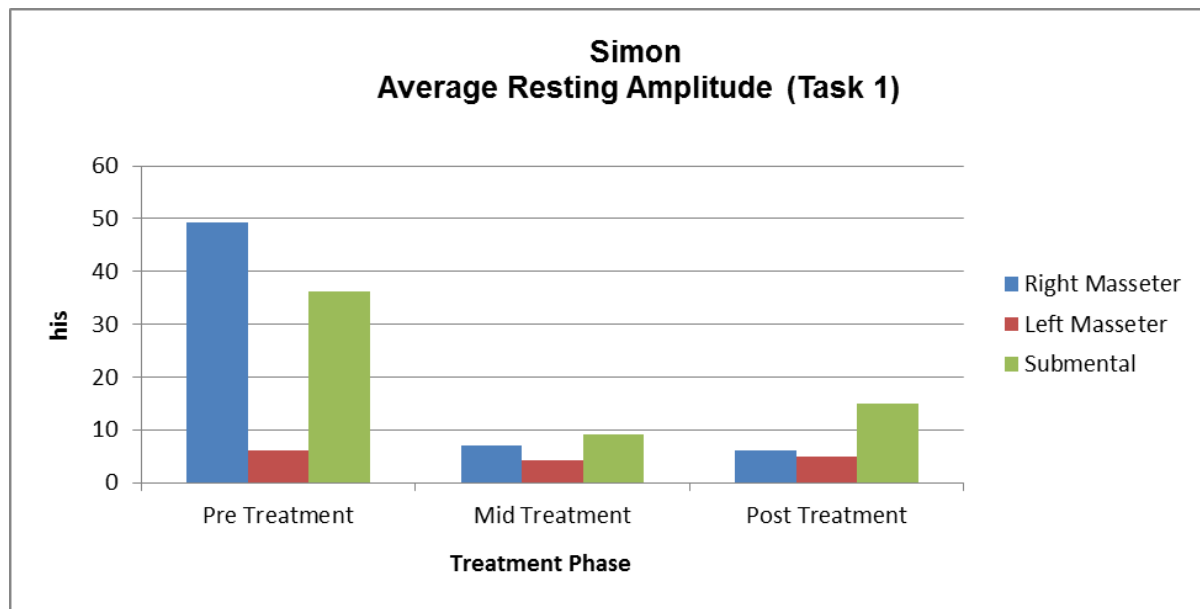


Figure 17: Simon - Average Resting Amplitude – Task 1



As shown in the graphs above, all three participants show an overall reduction post-treatment for average resting right masseter amplitude. For the left masseter John and Clare's average resting amplitude increases at each assessment. In contrast, Simon's left masseter resting amplitude reduces mid-treatment, and then increases slightly post-treatment, but shows a notable improvement overall. Clare and Simon's submental average resting amplitudes chart an overall reduction and improvement, however John's amplitude increases at the mid-treatment assessment.

Figure 18 – John - Average Return to Rest after Recruitment – Task 2



Figure 19 – Clare - Average Return to Rest after Recruitment – Task 2

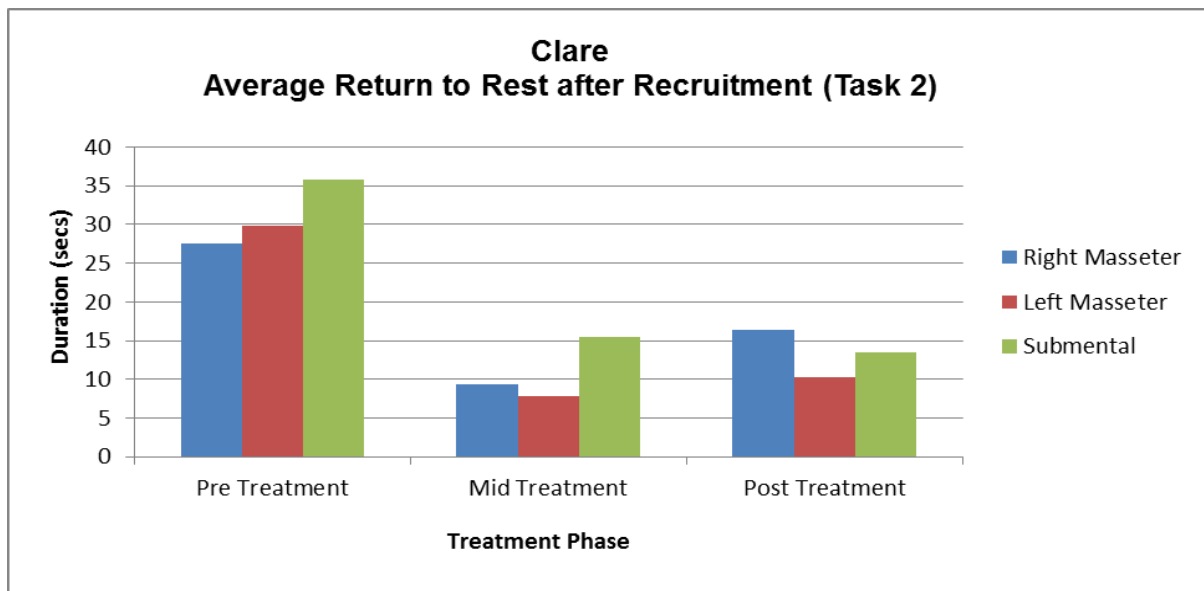
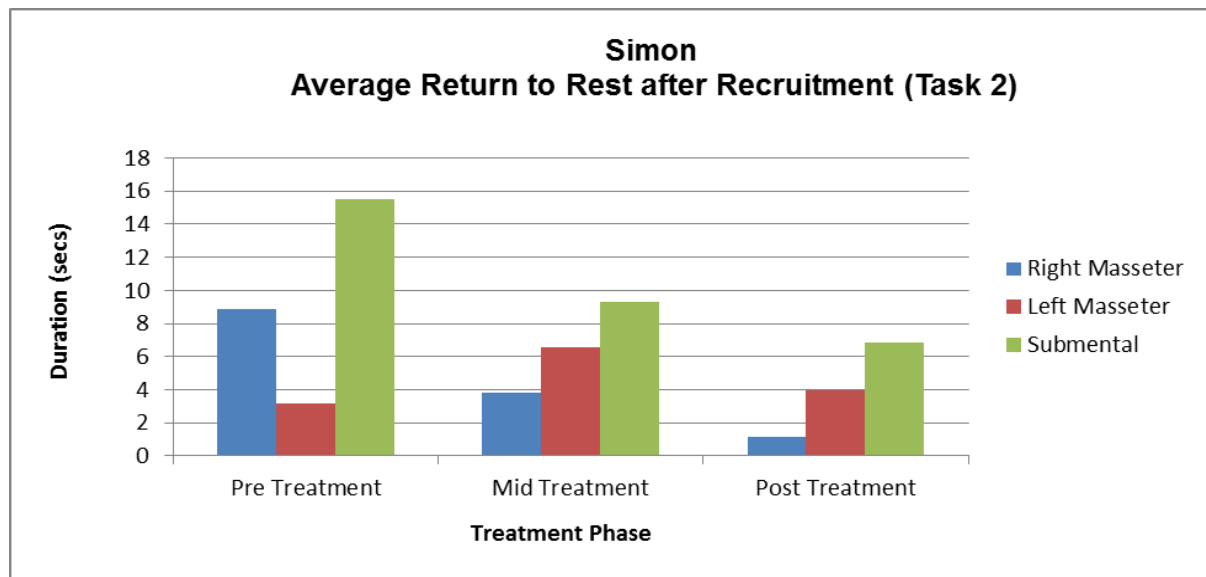


Figure 20 – John - Average Return to Rest after Recruitment – Task 2



As displayed in the graphs above John and Simon demonstrate a steady reduction in duration of return to rest after recruitment for their right masseter and submental muscles. Clare also shows an overall improvement, although her final post-treatment duration is slightly increased from her mid-treatment time for right masseter and submental muscles. John's duration of return after recruitment of left masseter improves, as does Clare's overall, despite a slight increase in her duration mid-treatment. In contrast Simon's average return to rest increases mid-treatment, and reduces post-treatment but still is greater post-treatment than the average return to rest after recruiting his left masseter than the duration measured pre-treatment.

DISCUSSION

This study hypothesized that active relaxation of increased muscle tone with sEMG is an effective treatment modality to facilitate the development of increased motor control in children with spastic Cerebral Palsy. Specifically, it hypothesized that increased motor control attained during motor control therapy with sEMG would have an observable impact on the participants' oral skills on chewable, non-chewable and thin liquids post-treatment as measured by a change in scores on the DDS. It also hypothesized that participants would show an improvement in containment of bolus during the oral stage post-treatment as measured by a decreased amount of anterior bolus loss

Oral motor control therapy with sEMG as an effective treatment modality

This study demonstrates that it is possible to use sEMG successfully with participants who have developmental disability. All the participants involved in the study were able to access the equipment and were able to complete treatment sessions using this modality, despite all participants having a diagnosis of mild-moderate cognitive impairment. Despite one participant being withdrawn due to non attendance they all showed an ability to gain some level of control over the increased tone in the masseter and submental muscle groups. This can be seen in the results by the reduction of amplitudes noted in the sEMG baselines of Task One and the reduction of duration of return to rest after recruitment on Task Two. By feeding the participants directly after treatment this study demonstrated that they could apply this new level of control during feeding. The improvement observed in feeding competency for Simon and Clare further supports this argument. This could have significant implications for therapy provision for this client group. As the review of the literature demonstrates, this study is the

first of its kind to successfully complete a full therapy program using sEMG and active relaxation to address oral stage dysphagia.

DDS discussion

The scores from the DDS demonstrate a change in feeding competency on non-chewable, chewable and fluids which can be argued is a direct result of the therapy programme administered. It is significant that all participants scored changes in their levels of containment and chewing ability, which correlates with the muscle groups targeted. This also suggests a reduction in tone, which enabled the participants to have more control opening and closing their mouth. This also demonstrates an increased ability to relax the muscles post recruitment more efficiently, reducing the impact of spasticity.

Simon and Clare's scores on the DDS demonstrated a pattern of improvement, decline, and improvement as they completed the treatment program. In motor learning studies it has been demonstrated that when a task is changed, as might be if there is a change in muscle tone, there is a period of reorganization in which function may appear as reduced. This is then followed by the improvement in skills (Christoforou-Gioules 2006). This pattern of decline followed by improvement can also be observed in Gisel et al's (1995) study of sensorimotor therapy in children with Cerebral Palsy. In their follow up of developmental profiles of children with Cerebral Palsy, Chen et al (2009) also found that different areas of development develop at different rates. Specifically they noted that developmental functions such as gross motor function, fine motor function and expressive language functions did not develop proportionally as the children matured.

The results from this study raise the question of whether this improvement in DDS scores due to a development of more functional oral skills was due to active relaxation of spasticity? Or was it due to a natural improvement or an improvement triggered by 6 weeks of one to one intensive therapy and daily increased practice of feeding? The fact that the most significant areas of improvement were chewing and containment would indicate improvement in the muscles targeted by the therapy programme. Current literature such as Francis et al (2004) has demonstrated that work on reduction of spasticity does translate into functional improvement. This study looked at arm function and reduction of spasticity using a botulinum toxin. This therapy could arguably be applied to other muscle groups, in the case of this study, submental and Masseter. The sEMG figures, as previously discussed, would suggest that all the participants reduced their average amplitudes significantly from their initial pre-treatment baselines. John for example reduced his right Masseter amplitude at rest by $2.8875(\mu V)$ from $6.195(\mu V)$ to $3.3075(\mu V)$. They therefore increased their control over their spasticity, as can be observed informally in the reduction of sEMG amplitudes and formally through the change in scores on the DDS. This therefore supports the hypothesis that increased motor control attained during motor control therapy with sEMG will have an observable impact on the participants' oral skills on chewable, non-chewable and thin liquids post-treatment as measured by a change in scores on the DDS.

It is possible to argue that the DDS is not a reliable measure in this study as it is a subjective screening tool, not an objective in depth assessment. This could lead to the conclusion that the changes in scores are due to the assessors' inconsistency in making observations, and not

to a true change in skills. In order to address this issue the inter-rater reliability of the DDS needs to be discussed. The DDS was standardized in a study of 427 individuals, mean age 33 years, comprising all the inhabitants of a residential facility for individuals with intellectual disability (Sheppard et al 1988). Standardization of the DDS was based on clinical judgment of presence and severity of dysphagia by speech- language therapists who were blinded to DDS screening results. Six speech-language pathologists, working in pairs, achieved 97% agreement in scoring DDS items for 21 participants. Therefore the DDS can be viewed as having high inter-rater reliability in this process. In order to reduce bias in this research the participants were assessed by a different speech-language therapist who had been trained in use of the DDS and who followed the guidelines for scoring given in the DDS manual. It was not possible to have the assessments duplicated by another therapist, as no therapist trained in the DDS was available aside from the researcher. In the initial research protocol it was suggested that all the assessments would be videotaped and the video reviewed by an independent speech-language therapist. However this proved impossible due to difficulties with equipment, availability of speech-language therapists and the distraction caused to the participants by the presence of the video camera. Therefore a limitation of this research is that the results have no independent inter-rater reliability. For future studies this is an important consideration which needs to be addressed.

Anterior Loss

All participants showed a positive decrease in anterior loss of food throughout the study between the percentages lost pre-treatment and post-treatment. Clare and Simon maintained this one month post study. This indicates that the participants' ability to control the submental

muscles and masseter muscle, that is to open and close their mouths efficiently, was a result of an improvement in motor control, developed by actively reducing the spasticity of those muscles. It could be argued that this increase in containment is due to an increase in the participants' attention and focus due to the intensive therapy and the impact of learning to focus during the treatment session. All the participants showed an observable increase in participation and focus as the treatment block progressed. However whether the improvement was caused by the treatment itself or this improvement in focus still supports the research hypothesis of an observable change. The outcome measure itself has high validity as it was replicated as accurately as possible. Each assessment was completed in the same room at the same time of day, with the same scales, amount of food clothing protectors and procedure each time. One unexpected outcome noted with anterior loss was that Clare and Simon demonstrated a slight regression with an increase of anterior loss of fluids one month after the last treatment session. This could be explained by a loss of the new skills developed since initial treatment. The final percentage one month from the last treatment session was still less than the initial pre-treatment assessment however, so some improvement was maintained. However it could also be argued that anterior loss is not only a result of increased spasticity, but is a result of other oral conditions prevalent in children with Cerebral Palsy such as delayed development of permanent teeth and significant malocclusions, as documented by researchers such as Rodrigues et al (2003). Therefore, whilst the participants in this study appear to demonstrate that a reduction in spasticity did equate to an improvement in anterior loss, it is important to note other factors which could contribute but are unable to be addressed through this treatment programme. Simon is an example of this as

he lost several teeth through the study and did not have any permanent teeth to replace them, which his parents noted when they commented on his chewing skills in the perception scales.

BMI

All three participants gained weight throughout the study and increased their BMI. This could be due to the increase in amount of food each day, as they ate after each session. However for Clare and John this increase in weight continued one month post-treatment. This suggests a positive impact on their oral skills and increase in intake. This would also correlate with a decrease in anterior loss. Current research has demonstrated a correlation between nutritional status and feeding components (Campos, Kent-Smith & Contas Santos 2007). This provided evidence for the use of BMI to show an improvement in function as was demonstrated by all participants in this study.

Perception Scales

There were notable inconsistencies between parents and school feeders' scores on the perception scales. This could be due to the time of day they are fed e.g. lunchtime vs. home in the evening, where the participants could be fatigued at the end of the school day.

Parents' scores on the perception scales were also inconsistent. This could be explained by a decline in skills of the participant. Simon lost 2 teeth during the treatment period which his parents noted may have made chewing difficult. The inconsistencies could also showed the subjectivity of the measurement tool itself, and parents' opinions could have changed from day to day and be an inaccurate picture of the participants' skills. This is further validated by

reports made to the researcher by the parents of continuous improvement, which was then not reflected in the scores they gave on the scale itself. The validity of perception scales as an outcome measure has been questioned, as they are highly subjective. However perception scales have been reported as an appropriate measure for use in single case research as they can play a critical role in intervention research (Kazdin 2011). This is because they can provide a direct measure of overt behavior by those familiar with the participants. In this study they provided a useful insight into parent/carer and school feeders' opinion of change in the participants feeding skills which is important to note in discussion. The parameters of the perception scales were designed to look at changes in skill and the feeders' experience in feeding the participants. As part of a larger model based research analysis, Blais et al (2010) discussed using questionnaire based outcome measures based on opinion and perception questionnaires. They noted the importance of content, order of questions and number of items in obtaining efficacious results. For future research it may be beneficial to revise these areas to make them more defined, with less room for interpretation and subjectivity.

sEMG amplitudes

All participants' sEMG average resting amplitudes decreased from the pre-treatment baselines, as did their return to resting baseline from recruitment on all muscle groups. Whilst not robust enough to be used as an outcome measure the data collected from the treatment session baselines does show an interesting progression in an increase in control. The baselines are not highly valid as a measure due to many influencing factors including time of day, participants' mood, health and attention. However it should be commented on that not only did all participants make a significant decrease in amplitude on task one

(relaxation) on both muscle groups targeted, they also were able to reduce the time from muscle recruitment to relaxation. It could be argued that the gains made are too significant to be as a result of external factors. Simon for example reduced submental amplitude from task one's pre-treatment baseline of 36.1975(μ V) to 8.995(μ V) mid-treatment. His post-treatment baseline of 15.045(μ V) shows an increase which could be influenced by lack of concentration or level of general wellbeing. It cannot be ignored that this is still a reduction of over half the original amplitude pre-treatment. This therefore indicates a change in level of control over spasticity. This pattern can also be seen in participants One and Two. This is important, as it shows that the participants in the study were able to learn the tasks required to gain more control over the targeted muscle groups, despite their disability. The use of animation, music and symbols to support the learning of active relaxation with the tool of sEMG were key elements of this. The language used in the treatment was chosen and assessed to ensure the participants were familiar with the terminology used in relation to the equipment and therapy programme. All participants were able to access the therapy effectively. This can be seen in the results of each session and the overall results in sEMG amplitude and the outcome measures, which suggest that in these three participants this treatment did effect a change in containment and chewing of solid foods. Therefore this provides strong evidence that this treatment is viable within this population. Therefore this study provides new important evidence for the use of motor control therapy with sEMG with children with spastic Cerebral Palsy. It complements previous research into this population such as McGrath (1979) and Marchant (2007).

Other positive outcomes

Simon and Clare's progression through the program also demonstrated an observable increase in their attention and listening skills. Both participants were able to listen and focus for increased length of time. By report from Simon's occupational therapist Simon's ability to use switch based computer programs developed alongside the research treatment program. This is because he developed the skill of using his muscles whilst looking and using the computer screen. This could also be due to receiving an hour a day of one to one input, which provides support for an intensive therapy approach when working with students who have developmental disability.

This study also demonstrates that a new treatment approach is possible for use with student within a special school environment. This study further supports the argument for the use of instrumentation and rehabilitation in treatment of spasticity and resulting dysphagia. By its successful use of the DDS as an outcome measure this study supports current research into its use as a valid measurement tool.

Unexpected Factors

Type of CP

As discussed previously the definition of type of Cerebral Palsy is a historically debated topic. The inclusion criteria for this study were that the participants have a diagnosis of spastic Cerebral Palsy. However it became apparent that two of the participants had evidence of dystonic movements. Further investigation into the participants' medical history has now confirmed this as a possibility, but the most recent records did not have this in the formal

diagnosis. Therefore the impact of dystonia for two participants could be significant in their results. However in the results the two participants were still able to progress through the treatment programme and both participants showed significant gains in control over spasticity shown in the sEMG amplitudes taken, and also in motor control during feeding as shown in the outcome measures. Therefore a conclusion could be drawn that this is an effective treatment for participants with spastic Cerebral Palsy and dystonia. The only participant who seems to have solely spastic Cerebral Palsy was withdrawn due to non-attendance so this leaves some questions unanswered. John had made significant gains in task one and two during therapy, so it would be interesting to look at other similar participants in future research who complete the programme. However the fact remains that it is very difficult to gain an accurate diagnosis of Cerebral Palsy type as many individuals are undiagnosed yet show features of dystonia. Therefore any study which uses participants from this population should take account of the impact inconsistencies in diagnosis and if it is possible to have a single diagnosis as an inclusion criteria. Researchers such as Chen et al (2010) have demonstrated that children with Cerebral Palsy have various patterns of development depending on their subtype which could have a significant impact on development of skills in therapy.

Inconsistency of sessions

Due to events outside of the researchers control none of the participants received the intended programme of 10 consecutive sessions per week over six weeks. John was withdrawn due to non-attendance, and Clare and Simon both missed one day a week for two weeks due to absence from school. This may be due to the research being carried out in winter, which is a

frequent time of ill health at school. However it could be argued that this did not have a negative impact on the results, as Clare and Simon both showed improvement in their outcome measures throughout the study.

Limitations of this study

Environment

This study was conducted in the participants school by the students current speech-language therapist, who was also the researcher so an issue of researcher bias can be raised when analyzing the results. This was addressed by having a different speech-language therapist administer the DDS assessment. The method of measurement for anterior loss was designed to be as objective as possible to reduce the possibility of interference by the researcher. Both these factors reduce the possibility of the researcher's bias affecting the scores, but it is impossible to rule bias out completely. Another area of concern is that the families and teacher aides of participants were well known to the researcher, so this could have impacted on the opinions given in the perception scales. It should also be noted that in the information form given to families it was explained that no negative impact would occur should they choose not to participate or to withdraw their child from the study.

Research Design

The research design has some limitations which affect the researcher's ability to draw conclusions from this study which can be applied to the general population of children with Cerebral Palsy. One of these is the small sample size of three participants. The participants were matched as closely as possible for type of Cerebral Palsy and level of cognition.

Despite this the participants do have key differences in the level of spasticity, cognition and attention skills which make it difficult to draw conclusions from them as a group. The participants and the families were well known to the researcher, and the research was conducted in the researcher's work place. This could lead to an argument of researcher bias. There is no blind or control group to compare outcomes in the development of feeding skills with no treatment as it was not possible to arrange, given the nature of the client group and limitations on the researcher.

However despite the limitation of its design this case series does provide an important starting point to answer the question of efficacious treatment for dysphagia in children with developmental disability. The measures used, in particular the DDS and the anterior loss measures provide strong evidence for the effectiveness of this treatment approach.

Next Steps

This study presents the method for a new treatment approach and shows a positive outcome for two of the three participants with the measures used. This study also demonstrates new possibilities for informing evidenced based practice in this area. Despite its limitations of design this study shows that active relaxation with sEMG can be used as an effective treatment modality to reduce spasticity in the three participants who participated in this study. Therefore it provides strong evidence for further research in this area with a larger range of participants.

CONCLUSION

Spasticity has a significant impact on the development of oral skills for children with Cerebral Palsy. In particular children with Spastic Cerebral Palsy demonstrate difficulty containing food in their mouth and chewing. This has an impact on their safety at mealtimes and their nutritional status. This study provides new evidence for the development of rehabilitation techniques for feeding in this population. It demonstrated that oral motor control therapy with sEMG is a viable treatment option for the two participants who completed the full course of treatment. These participants demonstrated that by learning to actively relax their masseter and submental muscles they were able to gain more control during feeding, and contain food in their mouth and chew more effectively.

Most importantly this study has demonstrated that even children with severe physical disability and a degree of cognitive impairment can successfully access sEMG equipment and learn techniques to reduce spasticity of their masseter and submental muscles. Therefore this study is an exciting beginning, and advocates for further larger scale research to take on the challenge of dysphagia in children with Cerebral Palsy. It argues for treatment which support the development of effective new oral skills, instead of compensating for the impairment.

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APPENDIX A - National Disability Ethics Central Region Committee

Approval



Central Regional Ethics Committee
Ministry of Health
Level 2, 1-3 The Terrace
PO Box 5013
Wellington
Phone: (04) 496 2405
Fax: (04) 496 2191
Email: central_ethicscommittee@moh.govt.nz

30 March 2010

Ms Emma Necus
21 Turnball Street
Thorndon
Wellington

Dear Ms Emma Necus

Ethics ref: **CEN/10/02/02**

Study title: A study of oral motor control therapy with surface electromyography (sMEG) biofeedback to develop active relaxation and reduction of spasticity with Spastic Cerebral Palsy

The above study has been given ethical approval by the Central Regional Ethics Committee.

Approved Documents

- Participant Information Form, Version 1, dated 10/01/2010
- Consent Form – Participants, dated 10/01/2010
- Information Form – Parents, Version1, dated 10/01/2010
- Perception Scale, dated 17/03/2010

Accreditation

The Committee involved in the approval of this study is accredited by the Health Research Council and is constituted and operates in accordance with the Operational Standard for Ethics Committees, April 2006.

Progress Reports

The study is approved until **1 June 2011**. The Committee will review the approved application annually and notify the Principal Investigator if it withdraws approval. It is the Principal Investigator's responsibility to forward a progress report covering all sites prior to ethical review of the project in **21 March 2011**. The report form is available on <http://www.ethicscommittees.health.govt.nz>. Please note that failure to provide a progress report may result in the withdrawal of ethical approval. A final report is also required at the conclusion of the study.

Amendments

It is a condition of approval that the Committee is advised if the study does not commence, or is altered in any way, including all documentation eg advertisements, letters to prospective participants.

Please quote the above ethics committee reference number in all correspondence.

APPENDIX B – Parent Information Sheet

Information Form

A study of Oral Motor Control Therapy with biofeedback (sEMG) to develop active relaxation and reduction of spasticity in school age children with Spastic Cerebral Palsy

Primary Researcher: Emma Necus (Speech Language Therapist & MSLT Student)
Kimi Ora School, 21 Turnbull Street Thorndon, Wellington tel 044729045

Emma is being supervised by: Maggie-Lee Huckbee (Dysphagia Researcher & Senior Lecturer, University of Canterbury) Van der Veer Institute, 66 Stewart St, Christchurch 8011 tel 03786 235

Your child has been invited to take part in a study taking place at Kimi Ora School during the school year 2010. You can choose not to allow your child to participate, and you can ask them to stop participating at any time. I am available for questions and discussions at any point in the study.

Your child was selected as they have Spastic Cerebral Palsy, attend Kimi Ora School, and have some difficulties chewing and managing foods and drinks in their mouth.

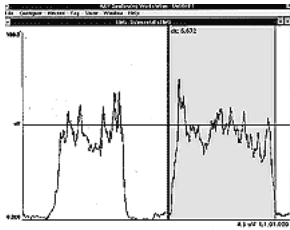
You can ask for an interpreter if you would like one.

What is Oral Motor Control Therapy?

Motor Control Therapy is a therapy technique which involves a series of exercises taught to your child by a researcher to help them learn to relax the muscles they use for eating and drinking. This is important as your child has high tone (spasticity) in these muscles, which affect how they chew and get food and drink ready in their mouths for swallowing..

What is Biofeedback (sEMG)?

As muscles contract, electrical signals are created within the muscle that may be measured from the surface of the body. The procedure that measures muscle activity from the skin is referred to as surface electromyography (sEMG). The small electrical current, or signal, which comes from active muscles, is detected by sensors placed on the skin directly above the muscles. The strength and pattern of the signal is displayed onto a computer screen and the data is collected in a software program. This provides a visual image like the one below on a computer screen of your child's muscles and how tense or relaxed they are:



The peaks in the Figure suggest a lot of activity (a lot of muscle movement) and the flat bottom parts are relaxed muscles. We can use this to help your child learn whether they are tense or relaxed, and about how they are moving.

How often will my child receive this therapy?

2 times a day for 30 minutes, 5 days a week for 6 six weeks.

Where and when will it take place?

During school time in the therapy room at Kimi Ora School.

How is this different than the therapy my child normally receives?

Your child already receives regular therapy input at school. Traditionally feeding therapy has looked at the problems your child has with eating during meals due to the difficulties have controlling their muscles and how reduce the risk of aspiration. This therapy looks at working directly on the issue of increased tone to help your child use their muscles more effectively.

What will happen in these sessions?

Your child will work through some oral motor control exercises with the researcher. This will involve spoken instruction to your child on relaxing their muscles your child will also be shown this using biofeedback, and given spoken instruction on targets they are trying to reach. These targets are different levels of waves on the computer, which will be flatter the more relaxed the child is. These targets will be adjusted so your child achieves success easily and then made harder at times so they learn motor control. Your child will be given positive feedback throughout the session. Your child will then be fed some juice yoghurt, pureed fruit and banana at the end of the session so they can use their muscles for eating after they have been working on them. Sometimes the researcher will videotape the sessions to show how the therapy is conducted.

Why is this good for my child?

If the therapy is successful it will improve you child's oral skills. This will make feeding time more successful and they will be able to move food around their mouths more effectively. This will increase the amount of food they swallow safely, and reduce the amount that falls out of their mouth during eating and drinking.

How will we know if it has worked?

Your child's eating and drinking skills will be assessed using the Dysphagia Disorders Survey, a screening assessment which looks at how your child eats and drinks. Your child

will be assessed three times, once at the beginning, half way and at the end of the 6 week therapy block. The assessment sessions will be videotaped so they can be looked at and checked if needed. Your child's clothing protector will also be weighed before and after they are fed in the assessment session, to see how much food has fallen out of their mouths. You will also be asked 4 questions about your child's eating and drinking at the beginning, middle and end of the study.

What will happen to the videotapes of my child?

The video tapes will be stored with your child's records at school. They will not be watched by anyone unless you have given your permission.

What are the risks to my child?

sEMG and Biofeedback pose no significant physical risk to your child. If they have tape allergies, the adhesive that secures the electrodes to the skin may cause irritation. Your child may become upset if they are unable to achieve their goals in the session, but this will be carefully monitored by the researcher and the targets changed so your child will achieve some success and always end the session on a positive. The researcher will also be in regular contact with you, so you will be able to raise any concerns at any time.

Your child's feeding after the therapy and during the assessment session will be carefully monitored for any increased signs of aspiration. Any incidences of aspiration will be discussed with you.

Your child's feeding skills may not change at all during the study which may show the therapy is not an effective treatment technique.

With your consent we will advise your child's paediatrician about his/her participation and performance in this study.

What will happen at the end of the study? Can I look at the results?

Your child's feeding needs will continue to be met by your Speech-Language Therapist. A summary of the results will be given to and explained to you and your Speech-Language Therapist by the researcher.

Who can I talk to about this, and who can I ask any questions of?

You can talk to the researcher at any time by contacting her at Kimi Ora School. You may have a friend, family or whānau support to help you understand the risks and/or benefits of this study and any other explanation you may require.

Will you explain to my child what is happening and why?

Yes. Your child consent will be asked for, and the therapy explained to them in a way they are able to understand.

Confidentiality:

No material that could personally identify you or your child will be used in any reports on this study.

Any records and notes from the therapy will be stored with your child's records at Kimi Ora and will be kept as per school's protocol.

If you have any queries or concerns regarding your child's rights as a participant in this study, you may wish to contact an independent health and disability advocate:

Free phone: 0800 555 050

Free fax: 0800 2 SUPPORT (0800 2787 7678)

Email: advocacy@hdc.org.nz

Ethics:

This study has received ethical approval from the central Ethics Committee, ethics reference number: CEN/10/02/02

Please feel free to contact the researcher if you have any questions about this study.

In the unlikely event of a physical injury as a result of your child's participation in this study, they may be covered by ACC under the Injury Prevention, Rehabilitation, and Compensation Act 2001. ACC cover is not automatic, and their case will need to be assessed by ACC according to the provisions of the Injury Prevention, Rehabilitation, and Compensation Act 2001. If your claim is accepted by ACC, you still might not get any compensation. This depends on a number of factors, such as whether you are an earner or non-earner. ACC usually provides only partial reimbursement of costs and expenses, and there may be no lump sum compensation payable. There is no cover for mental injury unless it is a result of physical injury. If you have ACC cover, generally this will affect your right to sue the investigators. If you have any questions about ACC, contact your nearest ACC office or the investigator. You are also advised to check whether participation in this study would affect any indemnity cover you have or are considering, such as medical insurance, life insurance and superannuation.

Thank you for your time

APPENDIX C – Subject Information Sheet

A study of Oral Motor Control Therapy with biofeedback to develop active relaxation and reduction of spasticity in children with Spastic Cerebral Palsy

Primary Researcher: Emma Necus (Speech Language Therapist & MSLT Student)

Kimi Ora School, 21 Turnbull Street Thorndon, Wellington tel 044729045

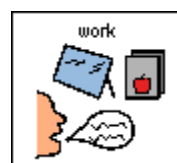
Emma is being supervised by:

Maggie-Lee Huckbee (Dysphagia Researcher & Senior Lecturer, University of Canterbury)

Van der Veer Institute, 66 Stewart St, Christchurch 8011 tel 03786 235



have been ask to take part in some special

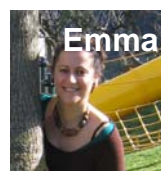


What is Oral Motor Control Therapy?

Motor Control Therapy is



with you and



looking at how

you move your



and learning and some new ways to



your



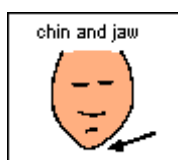
What is Biofeedback?

When you move your

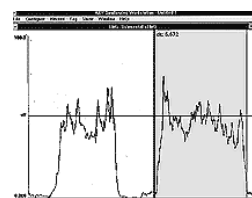


they give a signal which

we can measure with a patch on



this produces a wave like this



on



We can use this to

learn



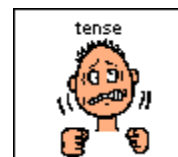
about whether

muscles



are

tense



or

relax



When? Where? For How long?

5 days



30 Minutes



6 Weeks



Where and when will it take place?

At



What will happen?

you

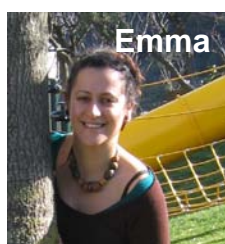


will

work



with



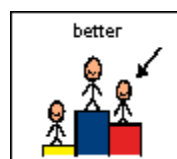
Why is this good?

If it works it may make your

eating



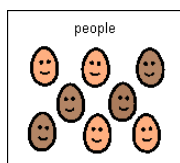
better



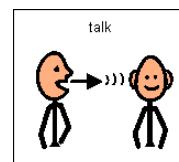
How will we know?

We will test your

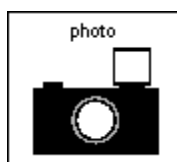
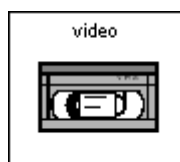
to



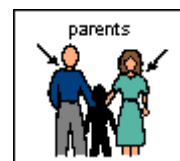
and



What happens to the

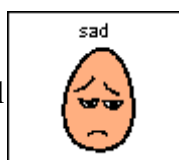


We will keep them and only show them to your

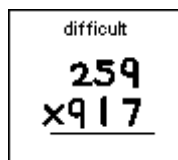


Any risks?

You may feel



if it is too

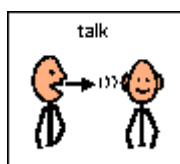


will help

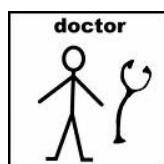
you feel



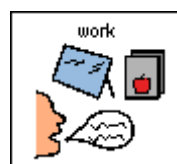
Emma will



to your



about



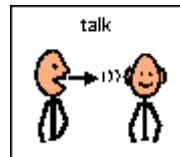
and tell him if

you become ill

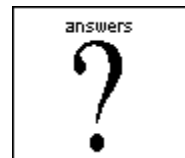
What will happen at the end?



will



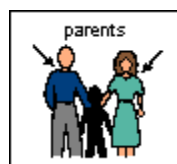
to me about what has happened and the



Who can I talk to about this?



and

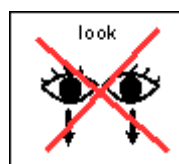


Confidentiality:

No



that could



will be used in



APPENDIX D – Parent Consent Form

Consent Form on behalf of my child/ward

A study of Oral Motor Control Therapy with sEMG to develop active relaxation and reduction of spasticity in children with Spastic Cerebral Palsy

English	I wish to have an interpreter	Yes	No
Deaf	I wish to have a NZ sign language interpreter	Yes	No
Māori	E hiahia ana ahau ki tetahi kaiwhaka Māori/kaiwhaka pakeha korero	Ae	Kao
Cook Island Māori	Ka inangaro au i tetahi tangata uri reo	Ae	Kare
Fijian	Au gadreva me dua e vakadewa vosa vei au	Io	Sega
Niuean	Fia manako au ke fakaaoga e taha tagata fakahokohoko kupu	E	Nakai
Sāmoan	Ou te mana'o ia i ai se fa'amatala upu	Ioe	Leai
Tokelaun	Ko au e fofou ki he tino ke fakaliliu te gagana Peletania ki na gagana o na motu o te Pahefika	Ioe	Leai
Tongan	Oku ou fiema'u ha fakatonulea	Io	Ikai
	<i>Other languages to be added following consultation with relevant communities.</i>		

I have read and I understand the information sheet dated _____ for children taking part in this study designed to evaluate the use of oral motor control therapy and sEMG to reduce spasticity in children with Cerebral Palsy.

I have had the opportunity to discuss this with the researcher and I am satisfied with the answers I have been given.

I have had the opportunity to use whanau support or a friend to help me ask questions and understand the study.

I understand that taking part in this study is voluntary and I may withdraw my child at any time and that this will in no way affect my child's continuing care and therapy input.

My child and I have had this project explained to me by Emma Necus (Speech-Language Therapist).

I understand that my participation in this study is confidential and that no material that could identify me will be used in any reports on this study.

I have had time to consider whether to take part in the study.

I know who to contact if I have any side effects from the study.

I know who to contact if I have any questions the study.

I _____ hereby consent for my child/ ward to take part in this study.

Date:

Signature:

Full names of researchers:

Contact phone number for
researchers:

04 4720945

Project explained by:

Emma Necus

Project role:

Researcher



Signature:

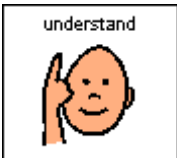
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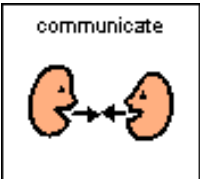


APPENDIX E – Subject consent form

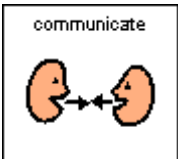
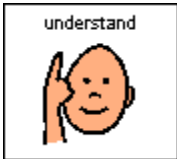
Consent Form - Participants

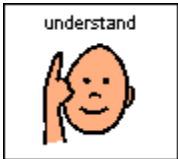

A study of Oral Motor Control Therapy with sEMG to develop active relaxation and reduction of spasticity in children with Spastic Cerebral Palsy

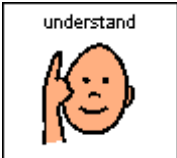
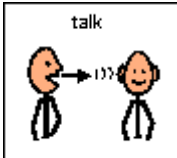

I have  the information sheet about the  I am going

to do and I 

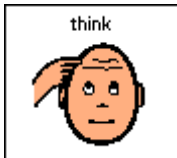

I have  with Emma about it and  and she 


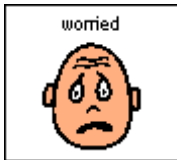
I have  with my parents/ friend about it to help me 


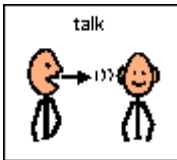
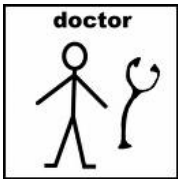
I  I can  whenever I want to


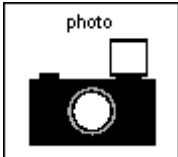
I  that everything that happens will be  about at 

and 

I have had time to  about this 

I know  to tell if I am  about the work.

Emma is  to  to my  about the work.

Emma is  to take a   of the

 we do.

I _____ hereby consent to take part in this study

Date:

My mark:

--

Full names of researchers:

Emma Necus telephone : 04 4720945
--

Project explained by:

Emma Necus (The Researcher)

Signature:

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Date:

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APPENDIX F – The Dysphagia Disorder Survey (Paediatric Addition)

DYSPHAGIA DISORDER SURVEY Pediatric Edition

TEST FORM

Justine Joan Sheppard, Ph.D.

NAME:	D.O.B:	CA:	M	F
ADDRESS/CENTER:	D.O.E:	I.D.#		
EXAMINER:	DIAGNOSIS			

SCORES:	Raw Score	Disability	Percentile
PART 1. Related Factors	_____		
PART 2. Feeding Competency	_____		
TOTAL	_____		
LEVEL OF EATING AND SWALLOWING COMPETENCY			
1. No Disorder	_____	_____	
2. Mild Disorder	_____	_____	
3. Moderate Disorder	_____	_____	
4. Severe Disorder	_____	_____	
5. Profound Disorder	_____	_____	

GENERAL COMMENTS: (medications, respiratory health, etc.) _____

WEIGHT LOSS or FTT: YES / NO Low 1-yr. Weight: _____ High 1-yr. Weight: _____		
Comment: _____		
GASTRO-ESOPHAGEAL DISORDER: YES / NO Satisfactory management Disorder Persists		
Comment: _____		
POSITIONING:	Appropriate	Inappropriate
Comment:		
DIET:	Appropriate	Inappropriate
Comment:		
FEEDING TECHNIQUE:	Appropriate	Inappropriate
Comment:		
SUPERVISION/ASSISTANCE	Appropriate for age	Inappropriate for age
Comment:		

EVALUATION SERVICES NEEDED:

DYSPHAGIA _____

POSITIONING _____

ADAPTIVE FUNCTION _____

MEDICAL/DENTAL _____

DIETARY _____

BEHAVIOR MODIFICATION _____

STAFF IN-SERVICE _____

OTHER _____

DYSPHAGIA DISORDER SURVEY Pediatric Edition

Justine Joan Sheppard, Ph.D.

NAME: _____ AGE _____

INSTRUCTION: Score item subsections: 0=normal/unrestricted 1=deficient/restricted
See User's Manual for scoring instructions for each item.

PART 1. RELATED FACTORS

					Item Score
1. BODY MASS INDEX:	WNL	< 10 th %ile	< 5 th %ile	HT _____	
	HT/WT: WNL	≤ 25 %ile	≤ 10 %ile	WT _____	
2. DIET:	cut up/whole	ground	puree	tube	
	Liquid unrestricted		restricted		
3. INDEPENDENCE:	self-feeder	assisted self-feeder			
	dependent feeder	tube feeder			
4. ADAPTIVE UTENSILS USED:	none	spoon	cup	tube	
5. POSITIONING:	upright independent	upright assisted	reclining		
6. POSTURAL CONTROL:	trunk stable	unstable			
	head/neck stable	unstable			
7. FEEDING TECHNIQUE/SUPERVISION:	normal	adaptive	mal-adaptive		

PART 1. SUB SCORE	
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PART 2. FEEDING & SWALLOWING COMPETENCY :

TEST FOODS: _____

	Non Chewable	Chewable	Liquid	Item Score
8. ORIENTING (alerting to food, moving toward food, mouth opening)				
9. RECEPTION (stripping spoon, biting, sipping from cup, taking appropriate bolus size, timing)				
10. CONTAINMENT (no dribbling or ejecting food or liquid)				
11. ORAL TRANSPORT (no residual in mouth after swallow, efficient bolus transit)				
12. CHEWING (chew adequate for bolus, no special placement required)				
13. ORAL-PHARYNGEAL SWALLOW (prompt, sequential liquid swallow, no gagging or multiple swallows)				
14. POST SWALLOW (absent coughing, wet breath sounds or wet voice) rpt/obs				
15. GASTRO-ESOPHAGEAL FUNCTION (absent vomiting or rumination) rpt/obs				

PART 2. SUB SCORES				
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APPENDIX G – Perception Scales

Please place a mark crossing the lines below to represent your response to the question stated above.

Thank you very much

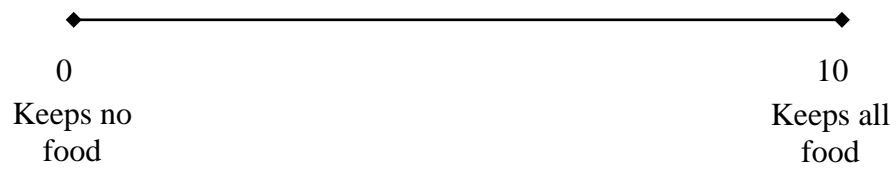
Emma Necus

(Researcher / SLT)

1. How well do you think your child chews food before they swallow it?



2. How well does your child keep food in their mouth whilst eating?



3. How successful do you feel your child is at feeding?



4. How happy are you with your child's eating?



5. How much does your child appear to enjoy eating and drinking?



6. How comfortable are you feeding your child?

